

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVI.

MARCH 13, 1896.

No. 6

A. A. COMMON, LL.D., F.R.S., President, in the Chair.

James Cavan, M.A., Eaton Mascott Hall, Shrewsbury, and
Thomas Edward Knightley, Clive House, Tulse Hill,
were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

William Banks, Optician, 30 Corporation Street, Bolton, Lancashire (proposed by J. R. Bridson) ;
Henry Frank Griffiths, Sherwood Villa, Angles Road, Streatham, S.W. (proposed by Rev. W. R. Waugh) ; and
Alfred Ernest Young, Assoc. M. Inst. C.E., Assistant-Surveyor and Chief Computer, Trigonometrical Survey of Perak, Taiping, Perak, Straits Settlements (proposed by James Simms).

One hundred and sixteen presents were announced as having been received since the last meeting, including, amongst others :—

J. Bauschinger, *Untersuchungen über die astronomische Refraction &c.*, presented by the author ; A. Cayley, collected mathematical papers, vol. ix., presented by the Cambridge University Press ; Galileo, *Opere*, Edizione nazionale, presented by the Italian Government ; Lick Observatory Contributions, Nos. 4 and 5, presented by the Observatory ; nine enlargements from

negatives of the Moon by MM. Lœwy and Puiseux, presented by Dr. Weinek ; photographs of the lunar eclipse 1896 February 28, presented by G. J. Newbegin.

On the Systematic Errors of Measures on Photographic Plates.

By H. H. Turner, M.A., B.Sc., Savilian Professor.

(1) In the January number of the *Monthly Notices* the Astronomer Royal and Mr. Dyson gave an account of the work done at the Royal Observatory, Greenwich, in measuring and reducing a number of plates for the Astrographic Catalogue. The material thus available for the study of the accidental and systematic errors of such measures is most valuable, for the number of overlapping plates discussed brings out the power of the photographic method, and also its limitations, in a very clear manner.

(2) The present note is concerned with one section of the paper only, viz., that headed "Systematic Error in the Determination of a ." It is therein shown that when a S.E. corner of one plate is compared with the N.W. corner of an overlapping plate, the deduced value of the constant a is positive ; whereas when a S.W. corner is compared with a N.E. corner, the value of a is negative— a being one of the constants in a pair of linear equations

$$x_2 - x_1 = ax_1 + by_1 + c$$

$$y_2 - y_1 = dx_1 + ey_1 + f$$

which represent the differences between the coordinates on the two plates. Such a systematic error is cumulative, and prevents the stepping from one plate to another with anything like accuracy.

(3) The sources of such an error may be numerous—errors in the réseau or the measuring scale, optical distortion, &c. It is remarked in the paper that as yet no investigation of them has been made. The object of the present note is to consider one possible cause—viz. tilt of the plate. The error noted is small, though it becomes serious by accumulation ; and it is possible that a slight want of perpendicularity of the plate to the line joining the centre of the object-glass and the centre of the plate might explain it in a manner developed in the sequel. I know that particular care has been taken to have this adjustment made at Greenwich, but the adjustments of a telescope cannot be examined every day, and possibly this particular adjustment may have been accidentally disturbed at some time. It is in any case advisable to consider the effect of such a disturbance.

(4) It has been shown in previous papers that if the normal

to the plate from the centre of the object-glass cuts the plate in the point (k, l) and not at the centre $(0, 0)$, then the measured coordinates (x, y) will be related to the standard coordinates (ξ, η) in the following manner :

$$x = \frac{(1+a)\xi + b\eta + c}{1 + k\xi + l\eta} \quad y = \frac{d\xi + (1+e)\eta + f}{1 + k\xi + l\eta}.$$

Where a, b, c, d, e, f , are all small, we have approximately

$$\begin{aligned} x &= \xi - k\xi^2 - l\xi\eta \\ y &= \eta - k\xi\eta - l\eta^2. \end{aligned}$$

(5) Suppose then that we first calculate ξ and η for the known stars from their R.A.s and N.P.D.s, as given by meridian observations, and then compare these standard coordinates with the measured coordinates. If in the first place we assume $k=0$, $l=0$ (*i.e.* that the plate is adjusted for tilt), we solve equations of the form

$$\begin{aligned} x - \xi &= ax + by + c \\ y - \eta &= dx + ey + f \end{aligned}$$

and hence determine a, b, c, d, e, f . But if this assumption of no tilt is false, these deduced values of a, b, c, d, e, f , will be slightly erroneous. The errors will depend upon the positions of the known stars, and we must make some assumption on this point. The best is that the known stars are distributed uniformly over the plate, which is a square of side $4s$ say (where $s=30'$ approximately). Further, it is here assumed that the procedure adopted is to group all the stars in the N. half of the plate, all in the S. half, all in the E. half, and all in the W. half, as mentioned in previous papers.

(6) Now in considering the effect of tilt we may neglect all other errors; and since we may put $x=\xi$, $y=\eta$ in the small terms, we may consider therefore the equations

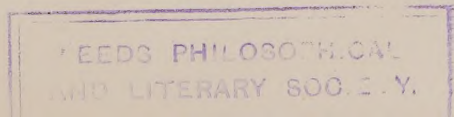
$$\begin{aligned} ax + by + c &= -kx^2 - lxy \\ dx + ey + f &= -kxy - ly^2. \end{aligned}$$

Integrating these over the N. half of the plate ($x=-2s$ to $x=+2s$, $y=0$ to $+2s$) we get

$$\begin{aligned} 0 \cdot a + 8s^3b + 8s^2c &= \frac{32s^4}{3}k - 0 \cdot l \\ 0 \cdot d + 8s^3e + 8s^2f &= -0 \cdot k - \frac{32s^4}{3}l. \end{aligned}$$

From the S. half we should get

$$\begin{aligned} 0 \cdot a - 8s^3b + 8s^2c &= -\frac{32s^4}{3}k - 0 \cdot l \\ 0 \cdot d - 8s^3e + 8s^2f &= -0 \cdot k - \frac{32s^4}{3}l. \end{aligned}$$



Subtracting S. half from N. we get

$$b=0, e=0, c=-\frac{4s^2}{3}k, f=-\frac{4s^2}{3}l.$$

Similarly from the E. and W. halves of the plate we should get

$$a=0, d=0, c=-\frac{4s^2}{3}k, f=-\frac{4s^2}{3}l.$$

The measured coordinates

$$\xi - k\xi^2 - l\xi\eta, \quad \eta - k\xi\eta - l\eta^2$$

are thus reduced, after comparison with ξ and η , to

$$\xi - k\xi^2 - l\xi\eta + \frac{4s^2}{3}k, \quad \eta - k\xi\eta - l\eta^2 + \frac{4s^2}{3}l.$$

(7) Now let another plate have its centre at $(+2s, +2s)$, and suppose its scale the same as that of the former and its orientation correct, and that the theoretical expressions have been applied to reduce the measures upon it to accordance with the measures on the first plate. If there were no error of tilt the coordinates of all stars would now exactly agree, except for accidental errors. But if the agate points against which the plates are brought into position for perpendicularity to the axis of the telescope be not correctly adjusted, there will be a systematic error of "tilt"—the same for both plates. From what precedes it will be seen that the ξ -coordinate of a star on the first plate (A) will now be

$$\xi - k\xi^2 - l\xi\eta + \frac{4s^2}{3}k$$

and of the same star on the second plate (B)

$$\xi - k(\xi - 2s)^2 - l(\xi - 2s)(\eta - 2s) + \frac{4s^2}{3}k$$

and the residual difference will be

$$\xi_B - \xi_A = s\xi(4k + 2l) + 2s\eta l - 4ls^2.$$

Similarly

$$\eta_B - \eta_A = s\eta(4l + 2k) + 2sk\xi - 4ks^2.$$

Let us now consider plates overlapping the other corners viz.

Plate C centre $(-2s, +2s)$

„ D „ $(-2s, -2s)$

„ E „ $(+2s, -2s)$.

The corresponding equations can be easily deduced, and the whole set will be as follows :—

$$\xi_B - \xi_A = s\xi(+4k+2l) + 2s\eta l - 4ls^2$$

$$\xi_C - \xi_A = s\xi(-4k+2l) - 2s\eta l + 4ls^2$$

$$\xi_D - \xi_A = s\xi(-4k-2l) - 2s\eta l - 4ls^2$$

$$\xi_E - \xi_A = s\xi(+4k-2l) + 2s\eta l + 4ls^2$$

$$\eta_B - \eta_A = s\eta(+4l+2k) + 2s\xi k - 4ks^2$$

$$\eta_C - \eta_A = s\eta(+4l-2k) + 2s\xi k + 4ks^2$$

$$\eta_D - \eta_A = s\eta(-4l-2k) - 2s\xi k - 4ks^2$$

$$\eta_E - \eta_A = s\eta(-4l+2k) - 2s\xi k + 4ks^2.$$

(8) To estimate the magnitude of these terms it should be remarked that s is approximately $30'$, or $\cdot 0087$ in circular measure; and if $k=10'$ (*i.e.* if the normal from the centre of the object-glass on to the plate cuts it only 2 réseau intervals away from the adopted centre) we have

$$4ks = \cdot 0087 \times \cdot 0087 \times \frac{4}{3} = \cdot 00010;$$

so that the differences of coordinates on two plates will be represented by terms such as

$$\xi_B - \xi_A = \cdot 00010\xi$$

$$\eta_B - \eta_A = \cdot 00005\xi + \cdot 00005\eta - \cdot 00010s.$$

These coefficients are just of the order of magnitude noticed by the Astronomer Royal and Mr. Dyson in their paper (*Monthly Notices*, lvi. pp. 125, 126).

The case of transformation from S.E. to N.W. corresponds to our transformation from C to A (or A to E); the case of transformation from S.W. to N.E. is that from B to A (or A to D). And we have in the first case

$$a_1 = s(-4k+2l), \quad e_1 = s(4l-2k), \quad (b+d)_1 = 2s(k-l)$$

and in the second case

$$a_2 = s(4k+2l), \quad e_2 = s(4l+2k), \quad (b+d)_2 = 2s(k+l).$$

Taking the means of the values given on p. 125 we have

$$a_1 = +\cdot 00011, \quad e_1 = +\cdot 00003, \quad (b+d)_1 = -\cdot 00003$$

$$a_2 = -\cdot 00012, \quad e_2 = +\cdot 00001, \quad (b+d)_2 = \cdot 00000$$

and we have thus six equations to determine k and l . Solving by least squares we get

$$2ks = -\cdot 000044, \quad 2ls = +\cdot 000009$$

which give the values for a_1 , a_2 , &c., shown in column C below :

	O.	C.	O-C.
a_1	+ '00011	+ '00010	+ '00001
e_1	+ '00003	+ '00006	- '00003
$(b+d)_1$	- '00003	- '00005	+ '00002
a_2	- '00012	- '00008	- '00004
e_2	+ '00001	- '00003	+ '00004
$(b+d)_2$	'00000	- '00004	+ '00004

the sums of the squares of the quantities being reduced in the proportion 284 to 62.

(9) The table which follows on p. 126 of the above paper gives the results when an overlapping plate is used to connect two plates in the same zone ; thus :

$$\begin{aligned}\xi_C - \xi_B &= (\xi_C - \xi_A) - (\xi_B - \xi_A) \\ &= -8ks\xi - 2ls\eta + 8ls^2\end{aligned}$$

from above ; and

$$\eta_C - \eta_B = 0\xi - 4ks\eta + 8ks^2.$$

With the above values of k and l we should have for the expression of these residuals

$$\begin{aligned}a &= -8ks = + '00018 & b &= -2ls = - '00001 \\ d &= 0 & e &= -4ks = + '00009.\end{aligned}$$

The mean value of a given in the paper from seventeen plates is + '00021. The values of e are not given in the paper, but were kindly furnished by the Astronomer Royal, on application, for all plates but one pair (2136-2227). Omitting this from a also we find mean values

$$a = '00020, \quad e = - '00004$$

and the observed and calculated values of e thus differ by '00013. This certainly throws some doubt on the reality of the "tilt" as a cause of the errors under discussion, unless there is some numerical mistake. But there is no doubt of the importance of this adjustment for "tilt," if plates are to be connected with one another in this way ; and it appears from what precedes that such an error should, if sensible, be detected in the comparison of plates with overlapping plates by means of the criterion

$$a = 2e.$$

(10) In conclusion, I venture to make a simple suggestion. Why should each region be photographed on a different plate? It would strengthen the determination of systematic errors immensely if several regions were photographed on the same plate without disturbing the telescope very seriously, or the plate in its holder at all. The stars of different regions might be identified by making the displacements from the 6^m to the 3^m exposure in different directions, or of different magnitudes, and the cases where stars of one region interfered with those of another would be rare. To have more stars on one plate would make it easier to measure, and there would be economy in many ways—of time in changing plates and developing, and of expense in actual plates and reproduction if any. We are trying this method at Oxford to see how it works.

Note on Professor Turner's Paper on the Systematic Errors of Measures of Photographic Plates. By W. H. M. Christie, M.A., F.R.S., and F. W. Dyson, M.A.

Professor Turner points out that the systematic difference in the value of the constant α on the two halves of the photographic plates taken at the Royal Observatory, referred to in a paper in the *Monthly Notices* for January, may be due to a tilt of the

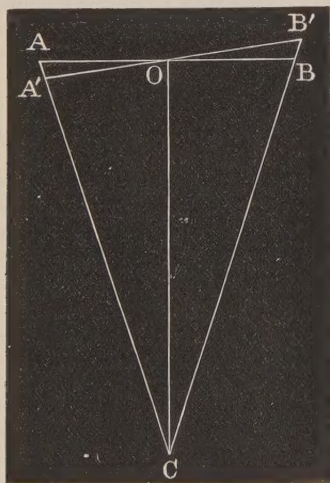


plate. It is easily seen geometrically that a tilt would have this effect. In the diagram O is the centre of a plate, C the centre

of the object-glass, and $A B : A' B'$ are the positions of two stars on plates without and with a tilt.

Let the tilt, $AOA' = i$, and let

$$\angle ACO = \angle BCO = \alpha.$$

If the tilt be uncorrected for, there will be an apparent scale correction of

$$\frac{OA}{OA'} - 1$$

for the star A' , and of

$$\frac{OB}{OB'} - 1$$

for the star B' .

Now

$$\text{and } \left. \begin{aligned} \frac{OA}{OA'} - 1 &= \frac{\cos(\alpha - i)}{\cos \alpha} - 1 = +\sin i \tan \alpha \\ \frac{OB}{OB'} - 1 &= \frac{\cos(\alpha + i)}{\cos \alpha} - 1 = -\sin i \tan \alpha \end{aligned} \right\}$$

The difference of these is $2 \sin i \tan \alpha$, and if α be taken as $30'$, this $= .0174 \sin i$. Equating this to $.00010$, the value of the discordance found on the Greenwich plates, we find that $i = 20'$.

It seemed almost impossible that there should have been any error of this magnitude, and reference to the adjustment book showed that previous to 1894 September 10 the tilt was about $5'$. On 1894 September 17 the tilt was readjusted by Mr. Criswick and reduced to between $1'$ and $2'$. The tilt was found to be the same on 1896 March 5, when it was measured by Mr. Dyson and Mr. Hollis.

An independent proof that the discordance in question is not caused by tilt is furnished by Professor Turner's criterion, that if it were there would be a discordance in e of the same sign and half the amount of the discordance in α . Comparison of the following figures shows that this is not the case.

The following table is a copy of that on p. 126 of the paper in the January number of the *Monthly Notices* above referred to, with the corresponding values of e added for comparison with those of α :—

Zone. °	Nos. of Plates.	Difference of <i>a.</i>	Means.	Difference of <i>e.</i>	Means.
65	1274-534	+ '00023	+ '00026	+ '00013	- '00007
	534-426	+ '00036		- '00014	
	426-2270	+ '00032		- '00033	
	2280-535	+ '00013		+ '00006	
66	443-444	+ '00026	+ '00019	+ '00019	- '00005
		+ '00034		+ '00028	
	444-1236	+ '00015		- '00024	
	1236-2290	+ '00007		- '00018	
	2290-2238	+ '00037		- '00028	
67	2279-2308	+ '00007	+ '00019	- '00006	+ '00001
	2288-2289	+ '00012		+ '00002	
	2289-2251	+ '00024		+ '00005	
	2251-1416	+ '00020		- '00005	
68	2136-2227	+ '00039	+ '00029	+ '00058	+ '00010
		+ '00023		+ '00021	
	2227-1397	+ '00013		+ '00001	
		+ '00006		- '00016	
	1397-2306	+ '00024		+ '00002	
69	2057-2058	+ '00045	+ '00004	- '00006	- '00002
	1323-2291	+ '00004		- '00002	

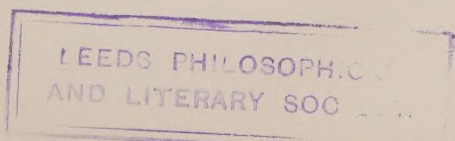
The plates whose numbers are less than 2227 were taken before the alteration in the adjustment for tilt on 1894 September 17. Examination of the figures in the above table shows that this did not sensibly alter the value of the discordance in question.

A Graphical Method of Solving Kepler's Equation.

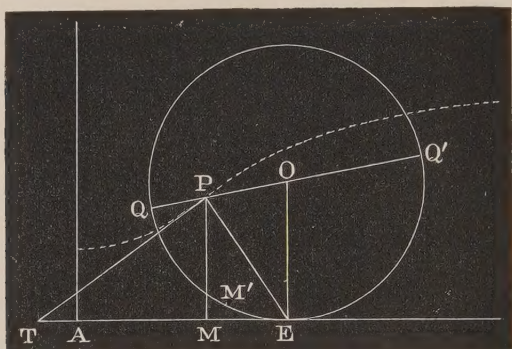
By H. C. Plummer.

(Communicated by H. H. Turner.)

The prominence which Dr. T. J. J. See in a recent paper published in the *Monthly Notices* gave to the Waterston-Dubois method of solving Kepler's Equation makes it appear likely that another graphical method may have some interest. The question of authorship to which that paper gave rise causes hesitation in claiming originality; but the method which is here described has not, so far as I am aware, been published previously. It is proposed to show a way of finding an approximate solution of the



equation $E - M = e \sin E$ corresponding to a given value of M , e being $< .1$ and $> .9$, and also to show how the error in the value of E so found may be discovered very simply by graphical means.



$M = E - e \sin E$ FIG. 1.

Let a circle (centre O) of unit radius roll along a straight line, and let a radius OQ be divided at P in the ratio $e : 1 - e$. Let A be the point where Q was originally on the line, M the foot of the ordinate through P , and E the point of contact of the circle at the instant.

Then

$$AM = AE - ME = \text{arc } QE - OP \sin POE.$$

Hence if $AM = M$, since the radius is of unit length, and $OP = e$, $\text{arc } QE = E$. But if M' is the point on the circle such that $QM' = AM = M$, M' was formerly coincident with the present position of M .

It thus appears that we may take an ordinary semicircular protractor, marking the point P which divides the radius through the zero reading in the ratio $e : 1 - e$. The division will be facilitated if the radius has a convenient scale marked along it. The protractor is placed in contact with a straight ledge at a fixed point, so that the reading at this point is M . The instrument must then be rolled along the ledge until the point P comes on the perpendicular to the ledge at the fixed point. The reading at the new point of contact is the required angle E .

The method just described has the great advantage of possessing the utmost simplicity of construction, requiring no specially prepared curve, and being practically instantaneous in application. On the other hand, it is only possible to obtain very roughly approximate results on account of the difficulty of avoiding an error, amounting to a considerable fraction of a degree, in reading off the point of the circumference in contact with the ledge. It is therefore necessary to slightly modify the method

in order to get more refined approximations. For this purpose it must be noticed (1) that since (fig. 1) the arc $QE=AE$, the readings may be taken along, or parallel to, the base, instead of round the circumference; and (2) that since OE is an ordinate, the abscissa of O may be read instead of the abscissa of E .

Let a board be covered with millimetre paper, one set of lines being parallel to a straight ledge at the side of the board. Let the length of the base (corresponding to 180°) be 450 mm. (say), so that 2.5 mm. correspond to a degree. Now make a semicircle of some material, stout cardboard, for instance, whose curved boundary is also 450 mm., so that its radius is

$$\frac{450}{\pi} \text{ mm.} = 143.24 \text{ mm.}$$

If the disc is covered with millimetre paper, with one set of lines perpendicular to one of the bounding radii, it is easy to find the point P which divides the radius in the ratio $e : 1-e$ very accurately. If the semicircle is now placed with this radius perpendicular to the base at one extremity, and then rolled along the base until P has the abscissa M (the extremity of the base being the origin of coordinates), the abscissa of the centre is E , and can be read off with no greater error than $0^\circ.1$, provided *no slipping* of the semicircle has been allowed to take place.

Let E_0 be the approximation to E thus found, and let $M_0=E_0-e \sin E_0$. Hence $\Delta M=M-M_0$ can be found at once.

Now

$$\begin{aligned} E &= f(M) = f(M_0 + \Delta M) \\ &= f(M_0) + \Delta M f'(M_0) + \frac{(\Delta M)^2}{2} f''(M_0) + \dots \\ &= E_0 + \frac{\Delta M}{1-e \cos E_0} - \frac{(\Delta M)^2}{2} \cdot \frac{e \sin E_0}{(1-e \cos E_0)^2} \cdot \frac{1}{1-e \cos E_0} + \dots \end{aligned}$$

Hence neglecting small quantities of order higher than the first,

$$E - E_0 = \Delta E = \frac{\Delta M}{1-e \cos E_0}.$$

Now $1-e \cos E_0$ can be read off at once, for referring to fig. 1,

$$1-e \cos E_0 = OE - OP \cos POE = PM$$

and it is therefore only necessary to read off the ordinate of P . The facility with which this correcting factor can be found seems to show that this method may be of considerable value in those cases where a second approximation by graphical means is desired. In practice it will probably be found best to treat the new approximation to E in the same way if approximations still closer are desired. It is, however, perhaps worthy of note that the calculation of the term in the above series involving a small

quantity of the second order is made very simple by the graphical method. For suppose the perpendicular at P to PE meets the base in T (fig. 1); then

$$TM = PM^2/ME = (1 - e \cos E)^2/e \sin E$$

and the coefficient need only be estimated roughly, since it multiplies a very small quantity.

The roulette traced by P is of course a prolate trochoid, to which PE is the normal at P, and TM is a sub-tangent. The instant when P falls on a given ordinate is always well marked, since the maximum inclination to the base of the tangent to the trochoid is $\sin^{-1}e$. This fact, which can be seen very easily, makes it clear that the error in reading off E is sensibly the same for all values of M, as well as for all values of e , for $\sin^{-1}e$ never exceeds 65° . This is an important point in favour of what may be called the trochoid method, for under certain circumstances the use of the curve of sines cannot give a very good result on account of the approach to parallelism of the curve and the line $x - ey = M$ at the point of intersection.

The method which has been here described is fully as general in its application as that of Waterston, and though I have had no opportunity of making an extended practical use of either method for the purposes of comparison, there seems to be no reason to anticipate any other than a successful trial for the trochoid method. The *slipping* of the disc along the base is the one thing to be feared, but this can be avoided by careful use and by giving a rough edge to the disc. Besides being equally well adapted to cases in which only rough approximations are needed, or in which the highest degree of accuracy attainable by graphical means is required, the trochoid method promises to be greatly superior when a limited use only is expected, in which case the trouble of constructing a reasonably accurate curve of sines would render the older method quite impracticable.

Hertford College, Oxford :
1896 March 9.

Observations of Comet α 1896 (Perrine-Lamp) made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

Greenwich Mean Solar Time.				Observer.	♂-★R.A.		Corr. for Refraction.	Log factor of Parallax.	♂-★N.P.D.	Corr. for Refraction.	Log factor of Parallax.	No. of Comps.	Apparent R.A.			Apparent N.P.D.	Comp. Star.			
1896.				d	h	m	s	m	s	''	''			h	m	s	°	'	''	
Feb.	25	7	2	57	A.C.	+0	27·63	+0·05	9·6496	-14	8·6	0·8163	3	22	1	17·47	50	35	27·0	a
	25	7	17	40	"	-0	5'31	-0·01	9·6384	+2	33·7	0·8298	6	22	1	38·00	50	33	3·2	b
Mar.	1	7	30	46	B.	+0	23·68	-0·01	9·7641	-13	34·8	0·6232	4	0	18	4·12	39	9	12·6	c
	1	8	2	46	"	+0	32·17	0·00	9·7565	+12	27·3	0·6760	6	0	18	47·87	39	8	0·3	d
	2	9	25	41	D.	+1	26·15	0·00	9·7390	+1	50·4	0·7679	4	0	44	11·14	38	29	38·8	e
	2	9	27	27	B.	+1	29·74	0·00	9·7394	+2	16·0	0·7709	2	0	44	14·73	38	30	4·4	e
	4	10	32	31	H.	-1	41·90	+0·01	9·7125	-7	9·1	0·8070	5	1	26	35·94	38	15	21·2	f
	4	10	32	31	"	-2	30·69	+0·01	9·7125	-6	29·3	0·8070	5	1	26	35·84	38	15	22·6	g

Notes.

The observations are corrected for refraction but not for parallax. They are also corrected for the error of inclination of the wires and for the motion of the comet.

Feb. 25.—Comet faint and difficult to observe owing to bright moonlight and slight haze.

Mar. 1.—Comet very bright, with nucleus.

The initials D, H, A.C., B., are those of Mr. Dyson, Mr. Hollis, Mr. Crommelin, and Mr. Bryant respectively.

Comparison Stars.

	Star's Name.	Assumed R.A. 1896 ^o .			Assumed N.P.D. 1896 ^o .	Authority.
		h	m	s	c ' "	
<i>a</i>	W.B. (2) xxi. 1499-500	22	0	51.00	50 49 30.9	Lund Astr. Gesell. Zones, 295, 300.
<i>b</i>	B.D. + 39°, No. 4751	22	1	44.55	50 30 24.0	" " 41, 51, 531.
	C.A. (N.), 281	0	17	41.89	39 22 56.0	Cambridge (U.S.) Astr. Gesell. Catalogue.
<i>d</i>	O.A. (N.), 294	0	18	17.17	38 55 41.3	" " " "
<i>e</i>	Lalande, 1284	0	42	46.33	38 27 58.9	" " " "
<i>f</i>	B.D. + 51°, No. 334	1	28	18.82	38 22 44.6	" " " "
<i>g</i>	Groombridge, 340	1	29	7.51	38 22 6.3	Greenwich Observations, 1887, 1890, 1891, Paris and Cambridge (U.S.) Catalogues.

Observations of Comets made at the Royal Observatory, Blackford Hill, Edinburgh.

(Communicated by the Astronomer Royal for Scotland.)

The following observations were made by Dr. J. Halm with the 15-inch Dunecht Refractor and the wire micrometer, except the second observation of December 11, which was made by Professor Copeland.

The adopted position of the new Transit House is

Lat. $+55^{\circ} 55' 28''.0$.

Long. West $12^m 44^s.2$.

The 15-inch Refractor stands $0^s.2$ east of the Transit House.

Swift (1895 Aug. 20).

1895.	M.T. Edinburgh.	($\odot$ -*) $\Delta\alpha$.	($\odot$ -*) $\Delta\delta$.	No. of Comp.	α App.	$\log p\Delta$.	δ App.	$\log p\Delta$.	Reduction to App. Pl.	*
		$\begin{smallmatrix} \text{m} & \text{s} \\ -0 & 34.02 \end{smallmatrix}$	$\begin{smallmatrix} ' & '' \\ -2 & 39.7 \end{smallmatrix}$	18, 7	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 1 & 26 & 34.70 \end{smallmatrix}$	8.786n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +3 & 40 & 24.0 \end{smallmatrix}$	0.848	$\begin{smallmatrix} \text{s} \\ +3.97 \end{smallmatrix}$	1
Oct. 16	11 3 49								$\begin{smallmatrix} '' \\ +27.3 \end{smallmatrix}$	1
17	9 45 9	$\begin{smallmatrix} \text{m} & \text{s} \\ -0 & 28.46 \end{smallmatrix}$	$\begin{smallmatrix} ' & '' \\ -5 & 4.0 \end{smallmatrix}$	36, 12	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 1 & 26 & 40.27 \end{smallmatrix}$	9.214n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +3 & 37 & 59.7 \end{smallmatrix}$	0.851	$\begin{smallmatrix} \text{s} \\ +3.98 \end{smallmatrix}$	1
18	10 52 41	$\begin{smallmatrix} \text{m} & \text{s} \\ -0 & 33.26 \end{smallmatrix}$	...	24, 0	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 1 & 26 & 45.60 \end{smallmatrix}$	8.788n	...	...	$\begin{smallmatrix} \text{s} \\ +3.99 \end{smallmatrix}$	2
18	10 59 6	...	$+2\ 17.5$	0, 9	...	...	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +3 & 35 & 36.7 \end{smallmatrix}$	0.849	$\begin{smallmatrix} \text{s} \\ +27.3 \end{smallmatrix}$	2

Perrine (1895 Nov. 16).

Nov. 18	18 13 29	$+7\ 27.78$	$-3\ 52.2$	9, 3	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 13 & 48 & 15.32 \end{smallmatrix}$	9.442n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +0 & 48 & 18.7 \end{smallmatrix}$	0.866	$\begin{smallmatrix} \text{s} \\ +1.90 \end{smallmatrix}$	3
---------	----------	-------------	------------	------	---	--------	---	-------	---	---

Brooks (1895 Nov. 21).

Dec. 7	9 8 48	$-2\ 42.30$	...	15, 0	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 8 & 21 & 36.06 \end{smallmatrix}$	9.644n	...	...	$\begin{smallmatrix} \text{s} \\ +5.63 \end{smallmatrix}$	4
8	11 13 11	...	$-1\ 16.8$	0, 3	...	...	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +45 & 2 & 55.3 \end{smallmatrix}$	0.513	$\begin{smallmatrix} \text{s} \\ -13.5 \end{smallmatrix}$	5
9	9 55 12	$+1\ 42.01$	$-1\ 28.3$	18, 9	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 7 & 57 & 29.81 \end{smallmatrix}$	9.683n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +48 & 36 & 38.6 \end{smallmatrix}$	0.572	$\begin{smallmatrix} \text{s} \\ +6.51 \end{smallmatrix}$	6
9	11 57 11	$+1\ 16.17$	$+2\ 29.0$	10, 5	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 7 & 56 & 23.71 \end{smallmatrix}$	9.527n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +48 & 55 & 14.2 \end{smallmatrix}$	0.303	$\begin{smallmatrix} \text{s} \\ +6.53 \end{smallmatrix}$	7
11	8 39 7	$-2\ 49.88$	$+0\ 3.8$	20, 10	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 7 & 30 & 9.03 \end{smallmatrix}$	9.762n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +54 & 59 & 41.7 \end{smallmatrix}$	0.567	$\begin{smallmatrix} \text{s} \\ +7.43 \end{smallmatrix}$	8
11	9 56 12	$-0\ 41.20$	$+6\ 37.0$	4, 4	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 7 & 29 & 19.74 \end{smallmatrix}$	9.717n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +55 & 9 & 17.6 \end{smallmatrix}$	0.370	$\begin{smallmatrix} \text{s} \\ +7.45 \end{smallmatrix}$	9
11	11 34 16	$-1\ 41.81$	$-5\ 10.9$	12, 6	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 7 & 28 & 17.15 \end{smallmatrix}$	9.560n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +55 & 21 & 7.0 \end{smallmatrix}$	0.976	$\begin{smallmatrix} \text{s} \\ +7.51 \end{smallmatrix}$	10
13	11 2 27	$-1\ 7.95$	$+4\ 23.9$	14, 7	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 6 & 56 & 2.04 \end{smallmatrix}$	9.600n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +60 & 21 & 24.9 \end{smallmatrix}$	0.088	$\begin{smallmatrix} \text{s} \\ +8.50 \end{smallmatrix}$	11
20	8 33 57	$+0\ 45.76$	$+5\ 18.9$	10, 8	$\begin{smallmatrix} \text{h} & \text{m} & \text{s} \\ 4 & 49 & 46.78 \end{smallmatrix}$	9.711n	$\begin{smallmatrix} ^{\circ} & ' & '' \\ +68 & 28 & 38.4 \end{smallmatrix}$	0.049n	$\begin{smallmatrix} \text{s} \\ +10.05 \end{smallmatrix}$	12

Mean Places of Comparison Stars.

No.	α 1895 o.			δ 1895 o.			Authority.
	h	m	s	$^{\circ}$	'	"	
1	1	27	4.75	+ 3	42	36.4	A.G.Z. Albany.
2	1	27	14.87	+ 3	32	51.9	" "
3	13	40	45.64	+ 5	52	27.9	" "
4	8	24	12.73	+ 40	34	37.1	A.G.Z. Bonn.
5	8	10	23.53	+ 45	4	25.6	" "
6	7	55	41.29	+ 48	38	18.9	" "
7	7	55	1.01	+ 48	52	57.1	" "
8	7	32	51.48	+ 54	59	47.1	A.G.Z. Hels. Gotha.
9	7	29	56.49	+ 55	2	49.4	Comp. with A.G.Z. Hels. Gotha, 5177.
10	7	29	51.45	+ 55	26	26.8	A.G.Z. Hels. Gotha.
11	6	57	1.49	+ 60	17	4.6	" "
12	4	48	50.97	+ 68	22	59.8	A.G.Z. Christiania.

Notes.

Comet *Swift* was always very faint and without a distinct nucleus.

Comet *Perrine* bright, with a nucleus of about sixth magnitude and a tail extending due north.

Comet *Brooks* exceedingly faint and of irregular outline; very difficult to observe on account of its want of any precise nucleus.

Observations of Comets made at the Royal Observatory, Blackford Hill, Edinburgh (15-inch Refractor and Wire Micrometer).

(Communicated by the Astronomer Royal for Scotland.)

☞ *Perrine (1895 Nov. 16).*

1896.	M.T. Edinburgh. h m s	(ϕ -*) $\Delta\alpha$. m s	(ϕ -*) $\Delta\delta$. ' ''	No. of Comp.	a App. h m s	Log $p\Delta$.	δ App. ° 21 58' 2	Log $p\Delta$.	*
Feb. 23	17 44 38	-0 39'34	-0 46'1	14, 6	19 46 34'26	9'442 ^m	+ 0 21 58' 2	0'860	1
Mar. 1	16 36 38	+1 31'12	-0 57'3	21, 7	19 46 52'84	9'484 ^m	+ 2 15 38'3	0'858	2
3	16 30 31	-0 22'14	+6 49'8	36, 12	19 46 48'69	9'483 ^m	+ 2 48 23'2	0'857	3
9	16 29 19	-2 31'90	+2 36'3	36, 12	19 46 9'59	9'460 ^m	+ 4 27 24'6	0'851	4

☞ *Perrine-Lamp (1896 Feb. 14).*

1896.	M.T. Edinburgh. h m s	(ϕ -*) $\Delta\alpha$. m s	(ϕ -*) $\Delta\delta$. ' ''	No. of Comp.	a App. h m s	Log $p\Delta$.	δ App. ° 21 58' 2	Log $p\Delta$.	*
Mar. 3	10 14 55	-1 58'36	-5 39'7	21, 7	1 6 59'69	9'670	+51 45 16'1	0'807	5
3	17 15 31	+1 43'86	-1 31'3	21, 7	1 12 57'53	9'562 ^m	+51 46 26'4	0'867	6
5	9 14 32	-0 34'94	+7 16'6	21, 7	1 43 12'65	9'723	+51 34 27'8	0'699	7
5	9 46 46	-0 41'95	+8 37'0	18, 6	1 43 34'57	9'711	+51 34 8'2	0'744	8
6	7 7 30	+0 39'00	+5 2'2	6, 2	1 57 23'96	9'672	+51 18 22'0	0'443	9
6	10 39 15	+1 59'95	+3 21'4	18, 6	1 59 32'59	9'681	+51 15 10'8	0'793	10
8	11 7 20	+4 23'22	-3 49'2	18, 6	2 25 24'93	9'663	+50 25 45'8	0'808	11
9	7 39 51	-0 56'62	+0 58'8	24, 8	2 34 37'93	9'667	+50 2 25'6	0'483	12
9	9 10 37	-1 12'56	+3 49'8	24, 8	2 35 16'69	9'711	+50 0 38'4	0'653	13
9	10 26 33	+0 14'41	-2 17'5	5, 5	2 35 48'96	9'695	+49 59 9'3	0'758	12

Mean Places of Comparison Stars.

No.	α 1896'o.			δ 1896'o.			Reduction to app. place.		Authority.
	h	m	s				s		
1	19	47	13 ⁶⁴	+	0	22 56 ¹¹ 5	-0 ⁰ 04	-12 ²	Schj.
2	19	45	21 ⁶²	+	2	16 48 ⁶	+0 ⁰ 10	-13 ⁰	Bonn. Obs. 1855.
3	19	47	10 ⁶⁶	+	2	41 46 ⁵	+0 ⁰ 17	-13 ¹	A.G.Z. Albany.
4	19	48	41 ²³	+	4	25 1 ⁹	+0 ⁰ 26	-13 ⁶	" "
5	1	8	59 ²¹	+	51	50 43 ¹	-1 ¹ 16	+12 ⁷	A.G.Z. Camb. Mass.
6	1	11	14 ⁸¹	+	51	47 44 ⁹	-1 ¹ 14	+12 ⁸	" "
7	1	43	48 ⁴⁴	+	51	26 56 ⁴	-0 ⁸ 5	+14 ⁸	" "
8	1	44	17 ³⁷	+	51	25 16 ⁴	-0 ⁸ 5	+14 ⁸	" "
9	1	56	45 ⁶⁹	+	51	13 4 ³	-0 ⁷ 3	+15 ⁵	" "
10	1	57	33 ³⁷	+	51	11 33 ⁹	-0 ⁷ 3	+15 ⁵	" "
11	2	21	2 ²¹	+	50	29 18 ⁶	-0 ⁵ 0	+16 ⁴	" "
12	2	35	34 ⁹⁰	+	50	1 9 ⁹	-0 ³ 5	+16 ⁹	A.G.Z. Bonn.
13	2	36	29 ⁵⁹	+	49	56 31 ⁷	-0 ³ 4	+16 ⁹	" "

Comet Perrine very faint on March 3 and 9.

Comet Perrine-Lamp bright and highly condensed towards the centre, but without a distinct nucleus.

The observations were made by Dr. J. Halm, except the last measure, on March 9, which was made by Professor Copeland.

Royal Observatory, Blackford Hill :
1896 March 12.

Discovery and Observations of Comet Brooks (d 1895).

By W. R. Brooks.

I have the honour to communicate to the Society some notes on the discovery and observations of my comet of November 21. While sweeping the south-eastern heavens with the 10-inch equatorial, at about 14 hours, standard 75th meridian time, I picked up a large nebulous mass, which I at once recognised as new.



Discovery field. Comet Brooks.

The discovery place was R.A. $9^h 51^m 50^s$, Decl. S. $17^\circ 40'$.

I give herewith a chart of the discovery field.

In a few minutes after securing the discovery position the sky, which up to that time had been remarkably clear, became clouded, but fortunately not before I had detected motion, which proved to be rapid and in a northerly direction. For over an hour not a star was to be seen in any part of the heavens, but by the driving-clock the telescope was kept on the object, hoping for a break in the clouds. This came in about an hour, and the direction of the comet's motion was ascertained beyond a doubt. The morning was intensely cold, the thermometer standing at 10° above zero, and when a little later I went down to the telegraph office, about one mile distant, to announce the discovery, it was snowing furiously.

Nearly a week of storms and cloudy weather followed, so that it was not until the sixth morning after the discovery that I was able to secure another observation of the comet.

It had in this interval, with its rapid motion of three degrees daily, moved over a great distance, so that on the morning of November 27, $15^h 40^m$, it was observed in R.A. $9^h 29^m 30^s$; Decl. N. $0^\circ 47'$; and the comet appeared larger and brighter than at discovery.

The following observations have since been made :—

November 28, $17^h 30^m$; R.A. $9^h 23^m 55^s$; Decl. N. $3^\circ 12'$.
The comet is slightly brighter than it was yesterday morning.

December 12, $9^h 30^m$ (evening observation); R.A. $7^h 9^m 30^s$; Decl. N. $58^\circ 19'$. Considerably fainter. The comet is now circumpolar, and evening observations are possible.

December 13, 7^h ; R.A. $6^h 55^m 20^s$; Decl. N. $60^\circ 23'$. Large, but pretty faint.

December 16, 9^h ; R.A. $5^h 58^m 10^s$; Decl. N. $65^\circ 30'$. Faint.

The comet has at all times appeared large, round, and with very slight central condensation.

Smith Observatory, Geneva, N.Y., (U.S.A.) :
1895 December 21.

Elliptical Orbit Elements of Comet b 1894 (Gale). By Rev.
Thomas Roseby, M.A., LL.D.

The following elements are based on four normal places, derived, the first two from Mr. Tebbutt's Windsor observations only, the last two from observations made at Windsor (N.S.W.), Melbourne, Liverpool, Greenwich, Lyons, Besançon, and Dudley (U.S.A.). The time interval between the extreme normal places is 78 days. I have to express my indebtedness to Mr. J. Tebbutt, F.R.A.S., of Windsor, Mr. R. T. A. Innes, F.R.A.S., and Mr. C. J. Merfield, of Sydney, for help without which the labour of this computation would hardly have been undertaken. The residuals for the middle places seem fairly satisfactory. The orbit elements indicate a period for the comet of 1001.18 years. The elements are :

Comet b 1894 (Gale).

τ 1894 April 13.393265 G.M.T.

π	$17^\circ 35' 52''.42$	} Mean equinox 1894.0.
Ω	$206 24 11.90$	
i	$86 58 55.73$	
$\log q$	9.9925685	
$\log e$	9.9957130	

Motion direct.

The residuals for the mean places are :

$$\begin{aligned} d\lambda, \cos \beta, &= -0''.59 \\ d\beta, &= -1''.64 \\ d\lambda_{II}, \cos \beta_{II}, &= +1''.48 \\ d\beta_{II}, &= +1''.27 \end{aligned}$$

It is to be remarked, however, in respect to this comet :

1. That the high inclination of the comet's orbit (nearly 87°) necessarily introduces an element of uncertainty into its heliocentric coordinates on the plane of the ecliptic.

2. That the very slow movement of the comet during its earliest observations introduces a similar element of uncertainty into the *times* of these observations. Thus the movement of the comet from April 3 to April 8 was so slow that it amounted in R.A. to only about $1''.0$ in 26 seconds of time, and in declination to only about $1''.0$ in 75^c seconds of time.

From these causes I shall not be surprised to find a considerable discrepancy between the above elements and those of the final definitive orbit, which orbit must itself, however, so it seems to me, be subject, more or less, to the same elements of uncertainty.

Parsonage, Marrickville, New South Wales :
1896 January 1.

Occultation of Jupiter, 1893 February 20 as seen at the Durham University Observatory.

(Communicated by the Director.)

The following are Mr. H. J. Carpenter's notes :—

Jupiter was found quite easily about 2 P.M., though it was faint. Unfortunately it clouded before the disappearance of the planet, and remained so till just before the reappearance, when the following observations were made :—

	G.M.T.		
	h	m	s
First seen, well off Moon's disc	3	7	26
Bisected	3	8	11 ^o
Last contact	3	9	40 ⁷

It was observed with the 6-inch equatorial with a power of 100.

The impression I formed was that the last contact was late, probably 2^s to 4^s. Some seconds before this time the Moon's limb had the appearance of being bulged in, or a piece cut out. This occurred so rapidly, and I was watching for "last contact," that I could not give much attention to it.

The sky was very hazy and *Jupiter* faint, but the Moon's limb was fairly well defined.

After the last time given *Jupiter* appreciably separated from the Moon.

Longitude 6^m 19^s.7 W. of Greenwich.

Fireball of 1895 November 22, 6^h 50^m. By W. F. Denning.

Having recently received two additional observations of this brilliant object, I have reinvestigated its path with fairly satisfactory results. It appeared at an epoch which is unusually productive in phenomena of this kind, and there is no doubt that the recent fireball furnishes another fine Taurid to the already numerous series recorded in past years.

I have observations from eight places—viz. Brighton, Bristol, Ealing (W.), Eastbourne, Ipswich, Isle of Wight, Rickmansworth (Herts), and Torquay—but at Bristol, Ealing (W.), and Ipswich the sky was overcast, and the observers could record no more than the sudden and intense illuminations of the firmament caused by the meteor.

At Bristol I thought the light was greater than the full Moon could have occasioned. At Ealing (W.) Mr. R. T. Lewis says “the effect was similar to that which might have been produced by the explosion of a large magnesium shell sufficiently brilliant to illuminate the entire sky.” At Ipswich Mr. A. Southgate remarks that “the sky, which was densely overcast, was suddenly and completely illuminated by a brilliant bluish light which appeared to penetrate the clouds. The effect was nearly equal to that of the Moon.”

At other places where the meteor itself was seen its brightness was remarkable. At Brighton Mr. A. Stanley Williams noted that it lit up the whole country to the north. At Torquay Mr. C. W. Priestley’s attention was called to the meteor by a strong light behind him, which he at first thought to be due either to the search-light of a vessel or a magnesium shell. At the Isle of Wight Capt. S. G. Horton, R.A., says “the meteor commenced as a brilliant white flash, as of a magnesium flash-light, and then followed yellow, red, and green in quick succession, a long streak of whitish light coming out from the main body and vanishing. A glow of yellow light remained where the first flash occurred for about 30 seconds and gradually died away.”

Several of the observers noted that the fireball was brightest in the first half of its course, and that from the place of its greatest outburst a fragment shot in the same direction, several degrees further. No detonation was heard. I have worked out the following details of the path :—

Fireball 1895 November 22.

Height when first observed	...	...	...	34 miles
Over ...	...	...	...	The Nore, river Thames
Height of end of brilliant part of course	...	...	...	22 miles
Over ...	...	...	...	Tilbury
Height at final extinction	...	...	...	17 miles
Over ...	...	...	...	Greenwich
Earth point	...	...	...	Reading

Real length of observed path	...	...	...	45 miles
Velocity	...	...	...	22 miles per second
Radiant point	...	...	...	$58^{\circ} + 22^{\circ}$
Direction of flight	...	...	...	East to west
Inclination of descent	...	...	...	26°

Very large meteors from *Taurus* are often seen in November, especially during the first week of that month and between the 20th and 23rd. Fireballs appeared in 1865 and 1884, on November 21, and in 1891, on November 22, several brilliant Taurids were visible in the evening sky, and "at Ramsgate were supposed to be rockets fired by the North Sandshead lightship. The life-boat at once put to sea. A heavy fog prevailed, and it was thought that a vessel had stranded on the Goodwin Sands, but on returning the coxwain reported that the lightship men had only observed two meteorites falling." In 1877 on November 23 two brilliant Taurids were seen. The radiant is at about $63^{\circ} + 22^{\circ}$, and I determined it from ordinary shower-meteors in three years as follows:—

		Meteors
1876 November 20	$62^{\circ} + 22^{\circ}$	11
1880 November 27	$63^{\circ} + 21^{\circ}$	8
1886 November 29–December 1	$64^{\circ} + 23^{\circ}$	6

Earlier in November the radiant appears to be a few degrees west of this. In 1896 on November 2 I witnessed a shower of 17 Taurids from $55^{\circ} + 9^{\circ}$, which is fully 15° S.S.W. of the position of the radiant in the last ten days of November.

Bristol 1896 March 5.

Note on a Curious Light (the Zodiacal Light?) as seen at Oxford, 1896 March 4. By H. H. Turner, M.A., B.Sc., Savilian Professor.

The evening of 1896 March 4 was brilliantly fine at times. After observing the transit of 6 *Canceri* (R.A. $7^{\text{h}} 57^{\text{m}}$), Mr. F. A. Bellamy, assistant in the University Observatory, went out to look at the sky, and his attention was immediately caught by what seemed to be the tail of a very bright comet in the west. He had often observed the zodiacal light in Oxford, but this appearance struck him as quite unfamiliar. He promptly brought out a 3-inch telescope to examine the object, but detected nothing definite; the faint stars showed distinctly through the light. After a minute or two he concluded that it must be an extraordinary apparition of the zodiacal light, which conclusion was confirmed by the position of the object, the direction passing nearly through the *Pleiades*, and the highest point being at an altitude of about 12° . He came up to the transit room to call my attention to it, and found me observing a transit of *Jupiter* (R.A. $8^{\text{h}} 9^{\text{m}}$). After this was concluded we went together to look at the phenomenon, but the light had then

become much fainter, though still brighter than Mr. Bellamy remembered to have ever seen the zodiacal light. It was fading rapidly, and within a few minutes was no longer very noticeable. The above transits fix the times with considerable accuracy as follows:—

					h	m	
Light first seen	...	...	...	...	9	14	G.M.T.
Much fainter...	...	...	...	...	9	26	"
So faint as not to be noticeable	...	...	...	...	9	30	"

These times seem quite inconsistent with the idea of the light disappearing by *setting* rather than by *fading*; and, though there were thin streaks of cloud near the horizon, these did not seem to cause the disappearance. There was no motion apparent.

An intermittent watch was kept on the sky till after midnight, but the light was not again noticed, though auroral light and streamers were seen in the north. It is quite possible that the light seen in the west was an auroral display. The evening was more cloudy later.

Besides the extraordinary brilliancy of the light the concentration of it along the axis of the cone (assuming it to be really the zodiacal light) was remarkable, suggesting at first nothing so much as the tail of a comet as bright as that of 1882. The width was estimated by Mr. Bellamy at barely 1° (two diameters of the Moon), and though I did not see it at its brightest my impression would accord with this. The edges were comparatively well defined, and did not present the gradual fading off usually seen in the zodiacal light. It may be remarked that there is some glare from gas lamps in that quarter of the sky as seen from the University Observatory, and much more now than in past years.

On March 5 Sir W. J. Herschel, who had also seen the light at Littlemore, about $2\frac{1}{2}$ miles away, came over to Oxford to make inquiries. He had independently taken the light for the tail of a comet—a fact which gives perhaps the best idea of its appearance.

Sir W. J. Herschel had independently written out his observations in a short note, which I here add *in extenso*.

“The Zodiacal Light—or is it not a Comet?”

“I have never seen the zodiacal light in England decidedly well. I have seen it elsewhere often enough to know its appearance, and it has always been a fairly evenly distributed light over a large area, fainter of course at the edges, and rather brighter towards the base centre, but not at all strikingly so. I have also seen fine comets. It seems almost impossible to compare such a comet in the open sky with what I know of the appearance of the zodiacal light.

“At 7.35 I left Mr. Sankey’s door to walk home: it faces north-westerly. I noticed light in the sky, studied it, and concluded that it must, by its inclination and limits, reaching up nearly to the *Pleiades*, be the upper part of the zodiacal light.

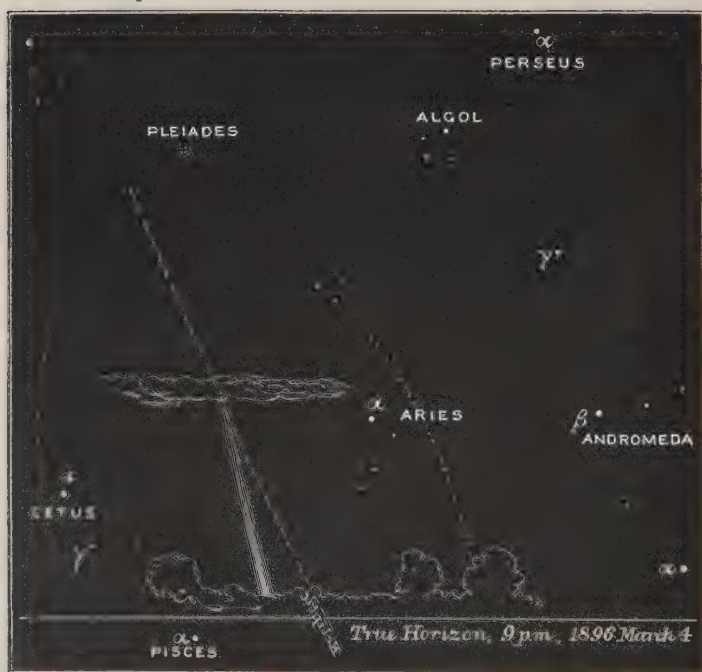
The lower part was hid in a bank of clouds, but the oval tilted outline was apparent enough to *my* eye to leave no doubt that it was the zodiacal light. I called Sankey out; we went into the dark to see it. He thought it was the afterglow of the Sun, but it was too late for that.

"As I came out of the gates I drew the attention of two residents passing by to it. They agreed that the Sun was much too long set, and that it sloped to the left, and was not a level arch. I fixed the slope by a straight edge through β and γ *Andromede*, and made the axis of the light parallel to this line.

"I then went home, and at 8.55 received a message from Mr. Sankey to come back and see 'the strange light.' I went back to the railway bridge, and then, to my intense surprise, saw a splendid 'comet' plunging head foremost into the distant trees exactly in the axial line of the zodiacal light, against a faint, clear sky, except that its upper end was lost in a thin, long, level cloud, which lay about—I speak by memory—two-fifths of the height of the *Pleiades* above the horizon.

"There was no room whatever for hesitation. Whether the zodiacal light had been there or not (and at this hour *there was no trace left* of what I had seen before at a quarter to eight), this was a *comet*.

"Its shape was as below :—



Supposed zodiacal light as seen 1896 March 4, 9 P.M.,
by Sir W. J. Herschel.

"The dotted line may be taken to show the area the zodiacal light had occupied. Spectators gathered, but in about ten minutes the mist obscured all but the upper one-third.

"The axis proved exactly parallel to the same two stars of *Andromeda*.

"It was as parallel-sided as I have drawn it, with very well-defined edges, *i.e.* as well defined as any comets ever are.

"The brightness of it was about that of a *fine* comet.

"The condensation of light towards the base was *quite* pronounced, and had a definite parallelism with its sides. *It did not correspond* to the condensation in a comet's tail before reaching the nucleus.

"We could not guess what was below the tree-tops, but it looked to me as if the head of the comet, if there, could not be far off; all that was certain was that the condensation of light was not nuclear, but axial. The tint of this part was rather ruddy, the rest ordinary pale yellow.

"The whole thing was a striking, sharply defined object, and therefore quite alien, to my knowledge, to the idea of the zodiacal light; and yet its position and my previous conclusion about the zodiacal light oblige me to suppose that I do not really know what the zodiacal light *can* look like. On the other hand, I cannot conceive how this second object could, an hour or so earlier (when it was concealed behind a bank of clouds), have been seen to extend over the zodiacal light area nearly up to the *Pleiades*. The axis of the 'comet,' by the way (being definite), passed *clear to the left* of the *Pleiades*.

"*Littlemore, near Oxford:*

"1896 March 4."

Later Sir W. J. Herschel sent me the following cutting from the *Evening Standard* referring to the same phenomenon:—

"*Meteoric Light.*

"To the Editor of the *Evening Standard*.

"SIR,—On Wednesday evening, a little after eight o'clock, there appeared in the western sky, a little above the horizon, a broad light, something like the tail of a comet, spreading up to about a third of a demi-semicircle of the heavens. The width of the light kept nearly the same till it tapered off a little, high up in the sky. There were on the sides smaller rays of light, emanating as it were from the central luminous body. It lasted for more than an hour after I first saw it; whether it was visible before eight o'clock I cannot say.—I. G. MONCKTON.

"*Coven Vicarage, Wolverhampton:*

"1896 March 6."

In reply to an inquiry as to any disturbance of the magnetic registers on the evening in question, the Astronomer Royal kindly sent me the following note :—

"Magnetic Disturbance of 1896 March 4-5."

"The date is omitted in Professor Turner's letter, but the reference would appear to be to the disturbance shown on the night of March 4-5 (active about midnight).

"There were minor movements on the preceding night (March 3), and small active movements preceding the major effects (above mentioned) from March 4^d 7^h.

"[H.F. and Dec. Phot. Records for 1896 (March 3^d-4^d, and March 4^d-5^d accompany this note.]"

Mr. H. F. Newall has also kindly sent me the following notes from Cambridge, where a ray was seen in the west, not quite at the same time, and was regarded as auroral. Mr. Goatcher noted on 1896 March 4 at 8^h 21^m a bright ray extended from top of trees to a *Trianguli*, of yellow colour, about parallel to α and β *Andromedæ*, and widening as altitude increased. It grew fainter, and was evidently shifting southwards.

8^h 31^m, ray extremely faint; reaches only to γ *Arietis*; is still parallel to original direction.

8^h 45^m, ray invisible. No quivering of light was observed in the ray.

10^h 30^m-13^h, greenish glow in magnetic N.; yellow and green auroral lines visible in spectroscope.

Note on the Zodiacal Light of 1896 March 4. By W. H. Robinson, Assistant at the Radcliffe Observatory.

(Communicated by E. J. Stone, M.A., F.R.S., Radcliffe Observer.)

The zodiacal light was seen at the Radcliffe Observatory between 7 and 8 P.M. on Wednesday, March 4.

It was very distinct and bright, extending in the usual lenticular form nearly to the *Pleiades*.

The sky at the time was very clear, but clouds prevailed from 8 until 9 o'clock, when observations were resumed with the heliometer. The N.W. sky was examined for a few seconds soon after 10 o'clock, but only a low, faint haze was then visible.

The zodiacal light is frequently seen here about the time of the vernal equinox. This year, however, it was visible as early as January 9 at 7 P.M.

Radcliffe Observatory, Oxford:
1896 March 12.

Letter from H. C. Russell. Supposed Observation of a Comet.

The Hon. Secretary
Royal Astronomical Society.

DEAR SIR,

If you have no better information about the object described, perhaps the facts stated by Mr. Parker may be worth publication. A great number of persons saw this object both in South Australia and New South Wales. Here it was cloudy every night, and our diligent search was not rewarded.

Notwithstanding the measure of the comet in feet and inches, Mr. Parker's account is much better than any others which have appeared in the local press.

In December our sky is so bright near sunset that you could not see a first-magnitude star in the position the comet is said to have occupied with reference to the Sun.

Yours truly,

H. C. RUSSELL.

It was not seen, I understand, either at Adelaide or Melbourne.

Sydney Observatory:
1896 January 18.

*Copy of a Letter from the Postmaster at the little village of
Hungerford, Long. 144° 30' East, Lat. 29° 0' West.*

SIR,

I have the honour to inform you, in reply to your memo. of even date, that the comet was first seen by several persons, including myself, on the 21st inst., shortly after sunset. It was visible fully an hour. Position was W.S.W., not due west as originally notified. Sky divided by six, *i.e.* 15°, would give approximate height when first seen, but it descended rapidly. The tail was apparently 5 feet long by about 18 inches to 6 inches wide. Nucleus small, fairly bright. It was quite distinct. Several people on Caiwarro Station, forty miles distant N.E., saw it on 22nd inst.

On 22nd it was very similar to 21st, but much brighter: 23rd and 24th appeared with greater brilliancy almost immediately after sunset, almost level with the horizon, but soon disappeared.

Sky been too cloudy since to see it.

I have the honour to be, Sir,

Your obed. Servant,

A. E. PARKER,

Postmaster.

The Government Astronomer,
Sydney.

Hungerford: 1895 December 27.

Note on the Sensibly Cylindrical Forms of the Pivots of the Transit Circle of the Radcliffe Observatory. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

The comparisons which have been made between the right ascensions observed with the Oxford, Cape, and Greenwich transit circles have shown the existence of small but sensible differences depending on the N.P.D. of the object observed. See *Monthly Notices*, vol. lv. p. 292.

The Oxford instrument was not originally provided with any suitable means of examining the form of the pivots; and so long as the form of the pivots of the transit circle of the Radcliffe Observatory had not been examined, it was possible to suppose that these discordances might be due to the deviations of the pivots from cylindrical forms. I have therefore for some time had under consideration the best means of testing the form of the pivots.

In the *Comptes Rendus de l'Académie des Sciences*, 1893 November 13, Mons. Maurice Hamy has called attention to the suitability of Mons. Fizeau's method of measuring the dilatation of crystals for the determination of the errors of the pivots of transit circles. See *Comptes Rendus*, 1862 June 23, and 1864 May 23.

This method appeared to me to offer great facilities for an examination of our pivots; and I have therefore obtained from Mr. Simms the necessary apparatus.

The general principle is simply that a shift of fringes of interference necessarily results from changes in the thickness of the layer of air between the plane surface of the object-glass of a *fixed* microscope and a plane reflector adjusted to sensible parallelism. The plane reflector is connected by levers with the pivots in such a way that its position is very sensibly affected by any slight deviations in the form of the pivots as the transit circle is turned around its axis; whilst its position remains unaltered and the fringes unaffected if no such deviations from the cylindrical form of the pivots exist.

The examination which I have made, with this instrument, of the form of the pivots shows that, although there are *traces* of slight variations from cylindrical forms, the errors are so small that they are practically insensible; the errors, in fact, are only such as would lead to differences of level error in different positions of the instrument of about $\frac{2}{100}$ of a second of arc.

It is certain, therefore, that the differences in right ascensions, to which attention has been called, are not due to pivot errors in the Radcliffe transit circle.

On the Proper Motions of certain Fundamental Stars.

By W. G. Thackeray.

As Dr. Chandler and Professor Newcomb have been lately discussing the question of Auwers' proper motions, *A.J.*, Nos. 364, 365, it appears a favourable opportunity to give the result of the discussion of some values of proper motions derived from the Greenwich observations, 1836-1893. The particular object in view at the time was to find a number of stars which had been consistently and continually observed over an extended period; but it was soon discovered that there were but few stars which could be so classed. Some were well observed at the beginning of the period, but not at the end, and *vice versa*; while others had awkward gaps at intermediate intervals. At present only thirty-six stars have been dealt with, and some of these can by no means be considered as fulfilling the wished-for conditions.

The right ascensions here dealt with were observed with the transit instrument from 1836 to 1850, and with the transit circle from 1851 to 1893. They have all been reduced to the epoch of 1890, and to the equinox of the 1880 Catalogue according to the following table, with Auwers-Bradley proper motions and Peters' constants of precession.

TABLE I.

Corrections to reduce Greenwich Observations 1836-76 to the Equinox of the 1880 Catalogue.

Year.	Name of Catalogue.	Corrections to		Year.	Name of Catalogue.	Corrections to	
		R.A.	Annual Mean R.A.			R.A.	Annual Mean R.A.
		s	s			s	s
1836	1840 Cat.	+ '055	- '026	1848	1850 Cat.	- '010	+ '062
1837			- '021	1849			'000
1838			- '031	1850			'000
1839			- '030	1851			'000
1840			- '031	1852			'000
1841			- '035	1853			'000
1842	1845 Cat.	+ '010	- '011	1854	1860 Cat.	- '003	- '003
1843			+ '078	1855			- '003
1844			+ '066	1856			- '013
1845			+ '087	1857			- '013
1846			+ '048	1858			- '013
1847			+ '060	1859			- '013
				1860			- '013
1861-67	1864 Cat.	+ '007	- '003	1868-76	1872 Cat.	'000	'000

The residual proper motion was therefore a direct correction to Auwers' values, and its amount was obtained in most cases by plotting every year's result and drawing the best straight line through the series. In those cases, therefore, where the correction to the proper motion is described as $\cdot 0000$ it is to be inferred that the observations were practically satisfied by the value found by Auwers. Out of the thirty-six stars twenty-three showed sensible corrections, which are mostly plus for the first twelve hours of R.A., and between declination -16° and $+16^\circ$, and minus for the last twelve hours of R.A., and between declination $+16^\circ$ and $+52^\circ$.

The north polar distances were observed with the Jones and Troughton circles 1836-39, with the Troughton circle 1840-47, with the Troughton and Jones Cape circle for the year 1848, with the Troughton circle 1849-50, and with the transit circle 1851-94.

The observations of 1836-47 have been reduced to colatitude $21''83$, those of 1849-50 to colatitude $21''94$, and those of 1851-93 to colatitude $21''90$. The observations 1851-93 have been further corrected where necessary to reduce them to Bessel's refractions, flexure $= \cdot 000$ and formula for $R-D = a + b \sin Z$, which latter correction practically implies that the value of the flexure is determined from positions of the instrument in constant use for observations in preference to the value obtained from a position which is never in use for observation (*i.e.* the horizontal position on the collimators), though theoretically the two values ought to be the same. In addition, corrections have also been applied for the wear in the microscope micrometers 1868-78. No corrections have been applied for Dr. Chandler's latitude variation.

The observations have all been reduced to 1890 with Auwers-Bradley corrections for proper motion, and Peters' constant of precession, and the annual results plotted down, and in most cases the best straight line drawn through the series represented the resulting proper motion, which is the direct correction to Auwers' value, and $\cdot 000$ is therefore to be considered as the sign that the Greenwich observations show no sensible corrections to the values found by Professor Auwers. Out of thirty-six stars twenty-three showed sensible corrections.

In *A.J.*, Nos. 313, 315, and 320, Dr. Chandler has discussed the observations made at Greenwich with the mural circles by Troughton and by Jones for the years 1825-48, and in *A.J.*, No. 361, he has found for thirty-four of these stars new values of proper motions from the following combinations:—

- (1) Pond's observations 1825-35, and those of the Greenwich Five-year Catalogue 1890.
- (2) Airy's observations 1836-48, and the Madison observations 1887-92.
- (3) The Pulkova Catalogue of 1845 and the Pulkova Catalogue 1885.

These results, combined with weights thirteen, eight, and nine respectively, are exhibited in *A.J.*, No. 364, as corrections to the proper motions of Auwers and Boss, and have been incorporated in the following table for comparison with the values deduced from the Greenwich observations 1836-93.

The following, Table II., contains a list of stars whose proper motions have been redetermined either by Chandler or at Greenwich: columns three and four give the approximate R.A. and Decl. for 1890; column five gives the corrections applied by Auwers to Bradley's observed declinations reduced to 1755 from the table given on p. 252, vol. ii. of the *Neue Reduction der Bradley'schen Beobachtungen*. These corrections for the circumpolar stars have been combined with weights according to the number of observation above and below pole. Column six gives the corrections to Auwers-Bradley's proper motions in R.A. deduced from the Greenwich observations 1836-93. Columns seven and ten give similar corrections to Auwers-Bradley and Boss' proper motions in declination. Columns eight and nine give Chandler's and Boss' corrections referred to above.

All these quantities are arranged in order of right ascension.

Table III. gives the same quantities, arranged in order of declination.

Gr refers to the proper motions deduced from Greenwich observations 1836-93.

A refers to the proper motions deduced by Auwers from Bradley's observations.

B refers to the proper motions deduced by Boss.

C refers to the proper motions deduced by Chandler, *A.J.*, No. 361, p. 3.

TABLE II.

Order of Right Ascension.

Differences of Proper Motion in (1) Right Ascension and Declination between Auwers-Bradley and Greenwich observations 1836-93; in (2) Declination between Auwers-Bradley and Chandler, "A.J.," No. 364, p. 29; in (3) Declination between Auwers-Bradley and Boss' Standard Catalogue; and in (4) Declination between Boss' and Greenwich observations 1836-93.

Ref. No.	Star's Name.	App. R.A. 1890.		App. Dec. 1890.	Auwers' corr. to Bradley. Decl.	Diff. of P.M. in R.A. Gr-A.	Diff. of P.M. Declination.			
		h	m				Gr-A.	C-A.	B-A.	Gr-B.
1	α Andromedæ	0	3	28 3	+0''56	0000	000	-009	-011	+011
2	γ Pegasi	0	8	14 6	+0'41	0000	000	-006	-006	+006
3	α Cassiopeiæ	0	34	55 9	-0'42	...	...	-002	-003	...
3a	μ Andromedæ	0	50	37 9	-0'55	-0038	-019	...	-042	+023
4	β Andromedæ	1	4	35 0	-0'05	-0005	-027	...	-038	+011
5	α Arietis	2	1	22 9	-0'18	-0004	-016	-018	-017	+001
6	α Ceti	2	57	3 7	+0'62	+0010	000	...	-013	+013
7	Aldebaran	4	30	16 2	+0'87	-0008	000	-011	-008	+008
8	Rigel	5	9	-8 3	+0'31	0000	000	...	-011	+011

B B

Ref. No.	Star's Name.	App. R.A. 1890.		App. Dec. 1891.		Auwers' corr. to Bradley. Decl.	Diff. of P.M. in R.A. Gr-A.	Diff. of P.M. Declination.				
		h	m	°	'			Gr-A.	C-A.	B-A.	Gr.-B.	
9	Capella	5	9	45	9	-0°63	-0040	"000	-0006	-010	+010	
10	β Tauri	5	19	28	5	+0°30	-0004	+015	+002	-001	+016	
11	α Orionis	5	49	7	4	-0°06	0000	-010	-020	-017	+007	
12	Sirius	6	39	-16	5	+0°18	-0010	-030	...	...	...	
13	Castor	7	28	32	2	+0°16	-0005	-012	+006	000	-012	
14	Procyon	7	34	5	7	+0°24	-0005	000	...	...	...	
15	Pollux	7	39	28	4	+0°31	-0006	000	-010	-006	+006	
16	Regulus	10	3	12	5	+0°30	0000	-018	-017	-019	+001	
17	α Ursæ Majoris	10	56	62	3	+0°09	...	...	000	-004	...	
18	δ Leonis	11	8	21	1	-0°12	...	...	-024	-027	...	
19	β Leonis	11	43	15	2	+0°86	0000	-020	...	-021	+001	
20	δ Ursæ Majoris	12	10	57	6	-0°10	...	...	+012	+005	...	
21	Spica	13	19	-10	6	0°00	+0006	-010	...	-020	+010	
22	η Boötis	13	49	19	0	+0°10	-0004	-008	...	-017	+009	
23	α Draconis	14	1	64	9	0°00	...	...	+002	-010	...	
24	Arcturus	14	11	19	7	+0°06	+0006	-017	-020	-023	+006	
25	ϵ^2 Boötis	14	40	27	6	+0°41	0000	+016	...	-009	+025	
26	β Ursæ Minoris *	14	51	74	6	-0°50	...	...	000	-009	...	
27	α Coronæ	15	30	27	1	+0°61	0000	000	-006	-006	+000	
28	α Serpentis	15	39	6	8	-0°04	+0003	-008	-015	-022	+014	
29	ζ Herculis	16	37	31	8	+0°11	-0014	-025	...	-009	-016	
30	α Herculis	17	10	14	5	+0°60	+0006	000	-003	-004	+004	
31	α Ophiuchi	17	30	12	6	+0°24	+0004	-014	-017	-020	+006	
32	γ Draconis	17	54	51	5	+0°20	+0004	000	...	-002	+002	
33	α Lyræ	18	33	38	7	-0°18	0000	-020	-020	-023	+003	
34	β Lyræ	18	46	33	2	+0°15	+0005	-024	-024	-034	+010	
35	ζ Aquilæ	19	0	13	7	+0°35	...	...	-016	-014	...	
36	δ Draconis	19	13	67	5	+0°26	...	...	+003	+006	...	
37	γ Aquilæ	19	41	10	3	-0°20	+0008	-020	-019	-016	-004	
38	α Aquilæ	19	45	8	6	-0°28	0000	-020	-014	-014	-006	
39	β Aquilæ	19	50	6	1	+0°24	+0014	-008	-016	-019	+011	
40	α^2 Capricorni	20	12	-12	9	+0°12	+0020	-016	...	-017	+001	
41	α Cygni	20	38	44	9	+0°60	0000	-015	-010	-011	-004	
42	α Cephei	21	16	62	1	0°00	...	...	+026	+017	..	
43	β Cephei	21	27	70	1	+0°25	...	...	+014	+007	...	
44	α Aquarii	22	0	-0	9	+0°98	+0004	000	...	-016	+016	
45	α Pegasi	22	59	14	6	+0°41	0000	-016	-018	-020	+004	

* One observation only in Bradley.

TABLE III.

*Order of Declination.**Difference of Proper Motion from Table I.*

Ref. No.	Star's Name.	Approx. Dec. 1890.		Approx. R.A. 1890.		Auwers' corr. to Bradley. Decl.	Diff. of P.M. in R.A. Gr-A.	Difference of P.M. Declination.			
		°	'	h	m			Gr-A.	C-A.	B-A.	Gr-B.
12	Sirius	-16	5	6	39	+0"18	-0010	-030	...	...	...
48	α^2 Capricorni	-12	9	20	12	+0"12	+0020	-016	...	-017	+001
21	Spica	-10	6	13	19	0"00	+0006	-010	...	-0200	+010
8	Rigel	-8	3	5	9	+0"31	0000	000	...	-011	+011
44	α Aquarii	-0	9	22	0	+0"98	+0004	000	...	-016	+016
6	α Ceti	+3	7	2	57	+0"62	+0010	000	...	-013	+013
14	Procyon	5	7	7	34	+0"24	-0005	000	...	...	...
39	β Aquilæ	6	1	19	50	+0"24	+0014	-008	-016	-019	+011
28	α Serpentis	6	8	15	39	-0"04	+0003	-008	-015	-022	+014
11	α Orionis	7	4	5	49	-0"06	0000	-010	-020	-017	+007
38	α Aquilæ	8	6	19	45	-0"28	0000	-020	-014	-014	-006
37	γ Aquilæ	10	3	19	41	-0"20	+0008	-020	-019	-016	-004
16	Regulus	12	5	10	3	+0"30	0000	-018	-017	-019	+001
31	α Ophiuchi	12	6	17	30	+0"24	+0004	-014	-017	-020	+006
35	ζ Aquilæ	13	7	19	0	+0"35	...	...	-016	-014	...
30	α Herculis	14	5	17	10	+0"60	+0006	000	-003	-004	+004
2	γ Pegasi	14	6	0	8	+0"41	0000	000	-006	-006	+006
45	α Pegasi	14	6	22	59	+0"41	0000	-016	-018	-020	+004
19	β Leonis	15	2	11	43	+0"86	0000	-020	...	-021	+001
7	Aldebaran	16	2	4	30	+0"87	-0008	000	-011	-008	+008
22	η Boötis	19	0	13	49	+0"10	-0004	-008	...	-017	+009
24	Arcturus	19	7	14	11	+0"06	+0006	-017	-020	-023	+006
18	δ Leonis	21	1	11	8	-0"12	...	...	-024	-027	...
5	α Arietis	22	9	2	1	-0"18	-0004	-016	-018	-017	+001
27	α Coronæ	27	1	15	30	+0"61	0000	000	-006	-006	+006
25	ϵ^2 Boötis	27	6	14	40	+0"41	0000	+016	...	-009	+025
1	α Andromedæ	28	3	0	3	+0"56	0000	000	-009	-011	+011
15	Pollux	28	4	7	39	+0"31	-0006	000	-010	-006	+006
10	β Tauri	28	5	5	19	+0"30	-0004	+015	+002	-001	+016
29	ζ Herculis	31	8	16	37	+0"11	-0014	-025	...	-009	-016
13	Castor	32	2	7	28	+0"16	-0005	-012	+006	000	-012
34	β Lyræ	33	2	18	46	+0"15	+0005	-024	-024	-034	+010
4	β Andromedæ	35	0	1	4	-0"05	-0005	-027	...	-038	+011
3a	μ Andromedæ	37	9	0	50	-0"55	-0038	-019	...	-042	+023

Ref. No.	Star's Name.	Approx. Dec.		Approx. R.A.		Auwers' corr. to Bradley. Decl.	Diff. of P.M. in R.A. Gr-A.	Difference of P.M. Declination.			
		1890.		1890.				Gr-A.	C-A.	B-A.	Gr-B.
33	α Lyrae	38	7	18	33	-0"18	0000	-020	-020	-023	+003
41	α Cygni	44	9	20	38	+060	0000	-015	-010	-011	-004
9	Capella	45	9	5	9	-063	-0040	000	-006	-010	+010
32	γ Draconis	51	5	17	54	+020	+0004	000	...	-002	+002
3	α Cassiopeiæ	55	9	0	34	-042	...	...	-002	-003	...
20	δ Ursæ Majoris	57	6	12	10	-010	...	...	+012	+005	...
42	α Cephei	62	1	21	16	000	...	...	+026	+017	...
17	α Ursæ Majoris	62	3	10	56	+009	...	...	000	-004	...
23	α Draconis	64	9	14	1	000	...	...	+002	-010	...
36	δ Draconis	67	5	19	13	+026	...	...	+003	+006	...
43	β Cephei	70	1	21	27	+025	...	...	+014	+007	...
26	β Ursæ Minoris*	74	6	14	51	-050	...	...	000	-009	...

* One observation only in Bradley.

The following general conclusions, making due allowance for the number of stars under discussion, may be drawn from these tables:—(1) That the proper motions deduced by Chandler and Boss agree very closely. (2) That there are systematic discordances either in the proper motions deduced by Auwers or in those deduced by Chandler and Boss. (3) That the Greenwich proper motions lie between those of Auwers and those of Chandler and Boss, and do not support the latter in attributing the systematic discordances as all due to Auwers. (4) That the corrections applied by Auwers to Bradley's observations (as far, at any rate, as the declinations covered by the clock-star system) are not in the main otherwise than beneficial, though they aggravate the large discordances shown to exist in the zones $+6^{\circ}8$ to $0^{\circ}3$ and $+35^{\circ}$ to $+38^{\circ}$ (see Professor Newcomb's paper on Boss' System of Declinations, *A.J.*, No. 365, p. 34). (6) That in any case the mean effect of these corrections is very small, $+0''.18$.

Now, if we take the mean of columns 5, 7, 9, and 10 of Table II. for those stars only whose proper motions have been re-determined at Greenwich, not including *Sirius* or *Procyon*, we shall get

Gr-A.	B-A.	Gr-B.	Effect of Auwers' Corr. on P.M.
-0088	-00153	+0068	-0016

Thus it would appear that the mean effect of Auwers' correction is to reduce the quantities Gr-A and B-A by $0''.0016$.

Now from Chandler's papers, *A.J.*, 364, p. 29, we find that the mean difference between Chandler's and Boss' systems of proper motions is $C-B = +0''.0021$, which would make $Gr-C = +0''.0047$,

and from his paper, *A.J.*, No. 361, we learn that in the reduction of the Greenwich mural circle observations he has adopted $38''.42$ for the mean value of the latitude. From independent sources we know the mural circles were $0''.07$ north of the present transit circle, which makes this adopted value of the mean latitude referred to the present transit circle $38''.35$, whereas the value adopted at Greenwich in the reductions of the Five-year Catalogue, 1890, is $38''.10$. For the purpose of obtaining values of the proper motion one or other of these sets of observations should be altered. Correcting Chandler's value, and taking fifty-five years as about the period over which the observations extend, and allowing for Chandler's weights, we get a correction of $+0''.0031$ to Chandler's proper motions; a quantity which satisfactorily accords with the value $+0''.0047$ given for Gr—C.

If we take the mean values of the three different determinations of all the proper motions given by Chandler, *A.J.*, No. 361, p. 3, we get

Gr. (5 year 1890) and Pond.

Madison and Airy.

Pulkova 1845 and 1885.

 $-0''.111$ $-0''.112$ $-0''.105$

from which it appears that the correction to the mean of the first two systems to reduce to that of Pulkova is $+0''.0065$; a value which also confirms the difference $+0''.0047$ shown to exist between Chandler and Greenwich, as also the validity of the assumption of an alteration of Chandler's Pond-Airy reductions.

Finally, in *A.J.*, No. 365, Professor Newcomb has pointed out that from the planetary theories (*Astronomical Constants*, p. 89) the general correction to Boss' system $= +0''.09 + 0''.42 T$, where T is the time from 1850 in terms of the century as unit; also that the value of the secular term may be in error some $\pm 0''.30$. This, again, confirms the mean correction of $+0''.0068$ to Boss' proper motions given by the Greenwich system 1836-93, and testifies to the general correctness of the latter system.

Errata to Paper on Meridian Observations of Sirius and Procyon at the Royal Observatory, Greenwich, 1836-94. By W. G. Thackeray.

Corrections to reduce Greenwich Observations 1836-76 to the Equinox of the Ten-year Catalogue, 1880 (Errata to Columns 8 and 9 of Table II., "Monthly Notices," lvi. 1, pp. 18, 19).

Year.	Name of Catalogue.	Corrections		Year.	Name of Catalogue.	Corrections	
		Corr. to Catalogue R.A.	to Annual Mean R.A.			Corr. to Catalogue R.A.	to Annual Mean R.A.
		(8)	(9)			(8)	(9)
		s	s			s	s
1836	1840 Cat.	+ '055	- '026	1848	1850 Cat.	- '010	+ '062
1837			- '021	1849			'000
1838			- '031	1850			'000
1839			- '030	1851			'000
1840			- '031	1852			'000
1841			- '035	1853			'000
1842	1845 Cat.	+ '010	- '011	1854	1860 Cat.	- '003	- '003
1843			+ '078	1855			- '003
1844			+ '066	1856			- '013
1845			+ '087	1857			- '013
1846			+ '048	1858			- '013
1847			+ '060	1859			- '013
				1860			- '013
				1861-67	1864 Cat.	+ '007	- '003
				1868-76	1872 Cat.	'000	'000

In consequence of these corrections to Table I. both *Sirius* and *Procyon* now appear to require small corrections to the adopted proper motions (those of Dr. Auwers) in right ascension, that of *Sirius*, $-0^s.0010$, making its proper motion $-0^s.0382$, that of *Procyon*, $-0^s.0005$, making its proper motion $-0^s.0479$. The following table embodying these corrections should therefore be substituted for Tables III. and IV. in the former paper, and the adopted secs. of R.A. 1890.0 should be further corrected for the new proper motions :—

Errata in Right Ascensions of Sirius and Procyon as given in Tables III. and IV. "Monthly Notices," lvi. I, pp. 22-25.

Year.	Sirius,		Procyon.	
	Mean Right Ascension.	Adopted Secs. of R.A. 1890'0.	Mean Right Ascension.	Adopted Secs. of R.A. 1890'0.
	^s	^s	^s	^s
1836	55'370	18'090	42'800	32'560
1837	58'060	'140	45'980	'600
1838	0'690	'120	49'090	'550
1839	3'390	'180	52'250	'570
1840	6'040	'160	55'380	'530
1841	8'660	'130	58'530	'530
1842	11'390	'200	1'750	'610
1843	14'000	'250	4'830	'630
1844	16'580	'170	8'000	'640
1845	19'210	'180	11'160	'680
1846	21'840	'120	14'280	'610
1847	24'430	'080	17'440	'640
1854	42'790	17'980	39'490	'690
1855	45'480	18'020	42'640	'700
1856	48'120	'000	45'790	'700
1857	50'700	17'940	48'910	'670
1858	53'280	'880	52'020	'640
1859	55'980	'940	55'160	'630
1860	58'600	'910	58'370	'650

The effect of these corrections is to make the agreement between Dr. Auwers' orbital corrections and the observations closer than before.

Variation of T Centauri (Ch. 4896). By A. W. Roberts.

In the *Monthly Notices* for November 1895 Colonel Markwick contributes a paper upon the variation of *T Centauri*.

This star was frequently observed at Lovedale during 1895, and as the elements of variation determined from these observations do not quite agree with those obtained by Colonel Markwick it is of present interest to deal with the Lovedale observations.

In determining the magnitude of *T Centauri* the following comparison stars were employed:—

C. Z. C.	R.A. (1875).			Dec.	Mag.
	h	m	s		
2115	13	35	10	33° 20' 9"	6.60
1910		31	43	32 28.5	6.70
2033		33	51	33 49.4	7.00
2003		33	21	33 43.4	7.30
1630		27	8	33 44.7	7.60
1711		28	22	33 22.6	7.75
1624		27	4	33 25.6	7.80
2386		39	17	33 8.8	7.93
2152		35	42	32 2.2	8.13
1746		28	58	33 44.0	8.50
1838		30	31	33 40.0	8.60
2299		38	6	32 38.7	8.60
2082		34	36	33 7.9	8.85
2362		38	52	32 50.4	8.90
2212		36	37	32 32.1	9.00
2240		37	7	32 34.1	9.00
2039	13	34	0	33 1.3	9.10

For magnitudes brighter than 6.5 the comparison stars used in observing 1, R and S *Carinae* were employed.

The magnitudes of the foregoing stars are determined from two reference points, viz. 6.8 and 9.3. The former magnitude is that of a star just visible to the naked eye; the latter is the lowest magnitude visible in a 1-inch glass.

The detailed observations are as follows :—

1895.	m		1895	m		1895	m	
Mar.	21.4	6.20	April	27.3	8.85	June	22.5	6.00
	22.4	6.20		29.3	8.90		25.5	6.40
	27.4	6.30	May	14.3	7.15	July	16.4	8.15
	29.5	6.40		15.4	7.10		25.3	9.05
April	3.3	6.80		18.3	7.00	Aug.	9.3	8.10
	12.3	7.65		20.3	6.65		12.4	8.00
	15.3	8.00		27.5	6.60		14.4	7.53
	21.3	8.20		31.6	6.20		15.3	7.40
	22.4	8.45	June	14.5	6.00		16.3	7.30
	24.4	8.75		15.5	6.20		21.3	7.00
	26.3	8.95		18.4	6.20		24.3	7.00
				20.4	5.90		27.4	6.75

Each observation is the mean of two others : one taken with the direct vision eye-piece, the other with the reversing eye-piece.

In this way the error arising from the position of the variable with relation to the surrounding comparison stars was eliminated.

Charting down the several observations we obtain the light curve given in the diagram, an examination of which yields the following elements :—

Period	91·2 days.
Min. to Max.	42 days.
Max. to Min.	49 days.
Epoch of Max.	1895 June 9.
Max. limit	5·85 Mag.
Min. limit	9·15 Mag.

The main points of difference between these elements and those determined by Colonel Markwick are the period and the magnitude at minimum phase.

Both Colonel Markwick's observations and my own indicate a minimum on or about April 25.

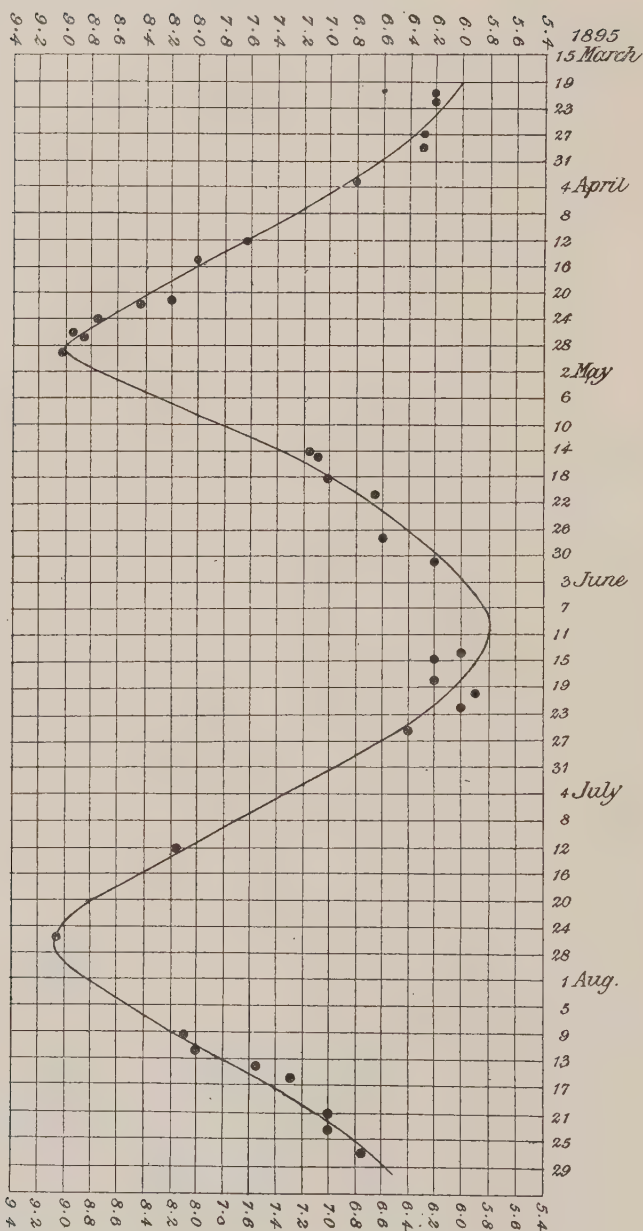
On April 25 and 26 Colonel Markwick estimated *T Centauri* to be of the 10th mag. On April 24 and 26 I found in the 1-inch glass, the limit of vision of which is 9·3 mag., that it was 8·75 and 8·95 respectively.

As regards the period, I think it will be found that a period of 91 days satisfies the data collected by Colonel Markwick in his interesting paper. Especially is this the case with the interval of 638 days between the minimum observed at Arequipa on 1893 July 27 and that observed by Colonel Markwick on 1895 April 26. Taking *seven* periods (instead of nine) to have elapsed between the two dates we obtain a mean period of 91·1 days.

The magnitudes given in meridian catalogues are very insecure data to base a determination of light period upon. As often as not the observer copies down the magnitude from his observing list, and even if an estimate of magnitude were made as the star crossed the field it would be but at best a rude guess. It is needless, therefore, to enter into an inquiry as to the agreement between the elements just given and the magnitudes in meridian catalogues.

But of more importance than this comparison between ephemerides computed from elements of variation and magnitudes in star catalogues is the method of determining the principal elements of variation—viz. the period. The usual method employed is to compare isolated measures made at or near one maximum with those made at another maximum.

It is evident that errors in estimating the magnitudes made use of in the computation will influence the result to no small extent. Further, the maximum phase of most long-period

Light Curve of *T Centauri*.

variables is not distinctly marked, and thus the determination of a point of reference depends a good deal upon the observer.

By far the better mode of determination is to compare light curves by superposition. By this method the period depends, not upon two or three isolated observations, but upon every observation made.

It was by this method, by comparing the curve (fig. 1) during March, April, May with that during June, July, August, that the period of *T Centauri* (91·2 days) given in this paper was arrived at.

Lovedale :

January 1896.

Observations of the Variable Star R Carinæ from 1890 December to 1895 August. By John Tebbutt.

In volumes xliv., xlvi., and li. of the Society's *Monthly Notices* comparisons of *R Carinæ* were published by me extending from 1880 May to 1890 June. Since the latter year I have been unable to keep up continuous observations of this interesting variable; still, scattered as the comparisons are, they may in combination with others—notably those made by Mr. A. W. Roberts, of South Africa—serve to throw light on its variations since 1890. I therefore enclose my results from 1890 December to August of the current year. While the variable was visible to the naked eye comparison stars were taken from the *Uranometria Argentina*. When the variable was telescopic the list of comparison stars employed was that given in *Monthly Notices*, vol. xlv. p. 17. It will be seen that the comparisons in 1891, 1892, 1894, and 1895 are sufficiently frequent to enable us to determine pretty accurately the maxima for those years. It also appears from a comparison of the observations made at Cordoba in 1871 with those made at Windsor in 1895 that the mean period of the star's variations from maximum to maximum is about 311 days, or about a day less than that which I deduced from observations down to 1886. I may here remark that there is a misprint on page 16 of the forty-fourth volume of the *Notices*, which I believe has not yet been corrected. The concluded magnitude opposite to 1882 December 12 should be 8·6 instead of 9·8.

Concluded Magnitudes of R Carinæ.

Date.	Mag.	Date.	Mag.	Date.	Mag.
1890 Dec. 30	8.0	1892 Jan. 31	5.7	1895 Apr. 4	6.9
1891 Jan. 12	7.0	Feb. 7	5.8	14	5.7
Feb. 7	5.6	19	6.3	21	5.5
11	5.5	Mar. 1	6.4	25	5.5
17	5.6	10	6.4	30	5.4
21	5.5	25	6.6	May 2	5.4
27	5.5	May 31	9.1	6	5.3
Mar. 3	5.6	Dec. 21	6.2	11	5.2
8	5.5	1893 Apr. 10	9.2	13	5.1
16	5.6	1894 Apr. 2	8.9	16	5.2
21	5.7	June 26	6.1	1	5.3
30	5.8	30	6.1	21	5.4
Apr. 6	5.9	July 7	5.7	25	5.5
10	5.9	15	5.8	26	5.6
17	6.0	20	5.9	29	5.7
21	6.3	28	6.0	June 3	5.8
30	6.4	Aug. 4	6.3	8	5.9
May 5	6.5	18	6.9	11	6.1
17	6.7	24	7.3	16	6.3
18	6.9	1895 Feb. 13	8.6	19	6.3
June 3	8.0	18	8.5	24	6.5
Dec. 30	5.3	27	8.3	27	6.5
1892 Jan. 2	5.3	Mar. 8	8.2	July 9	6.9
15	5.5	19	7.7	25	8.0
21	5.6	25	7.6	Aug. 21	8.5
24	5.6				

The Peninsula, Windsor, N.S. Wales:
1895 December 8.

Results of Double-star Measures with the 8-inch Equatorial at Windsor, New South Wales, in 1895.
By John Tebbutt.

Ref. No.	Star.	Observed Magnitudes.	Approx. Place of Star 1850. R. A. Dec. S.	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. Obs.	Mag. Power.	Eyes.	Hour-angles. h. m.	h. m.	Weight, 1 to 5
1	<i>p</i> Eridani	6, 6	5 ^h 44 ^m 56 ^s	.830	225° 5'	10	7".64	8	300	R	3 4 E	2 31 E	3
2	"	...	"	.871	223° 5'	10	...	...	300	P	0 53 E	0 35 E	4
3	"	...	"	.931	225° 1'	10	...	...	300	R	0 37 E	0 17 E	3
4	"	...	"	.936	222° 6'	10	7' 41"	6	300	P	1 13 E	0 42 E	2
5	"	6, 6	"	.977	225° 1'	10	7' 61"	6	300	R	3 25 W	3 53 W	4
6	"	6, 6	"	.983	224° 4'	10	7' 41"	6	300	R	1 12 W	1 37 W	3
7	"	6, 6	"	.988	224° 8'	10	7' 38"	7	300	R	2 9 W	2 39 W	3
8	"	6, 6	"	.997	225° 3'	10	7' 35"	7	300	R	2 17 W	2 40 W	4
9	Lacaille 2145	6, 6	48 27	.257	28° 5'	10	1' 55"	4	300	P	3 0 W	3 37 W	4
10	"	6, 6	"	.260	29° 7'	10	1' 86"	7	300	P	3 6 W	3 35 W	5
11	"	...	"	.263	29° 3'	6	...	...	300	P	3 54 W	4 23 W	3
12	"	...	"	.266	30° 2'	10	...	...	300	P	3 46 W	4 1 W	4
13	"	...	"	.301	30° 6'	10	...	...	300	P	3 59 W	4 22 W	3
14	"	7, 7	"	.304	31° 4'	10	1' 50"	6	300	P	3 41 W	4 9 W	4
15	Stone 4019	6, 8	47 36	.266	27° 5'	10	0' 8"	Est.	300	P	2 21 W	2 52 W	3
16	δ Argûs	3, 6	54 19	.285	156° 1'	8	...	...	535	...	1 38 E	1 10 E	

Ref. No.	Star.	Observed Magnitudes.	Approx. Place of Star +895°.	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. Obs.	Mag. Power.	Eyes.	Hour-angles.	Weight, 1 to 5.
			R. A. h m	° ' "			"				h m	
17	δ Argūs	4, 7	8 42	54 19	165.7	10	...	...	535	P	3 22 W 3 48 W	4
18	"	3, 8	"	"	157.3	10	...	...	535	P	1 36 W 2 19 W	5
19	"	3, 8	"	"	162.4	10	...	...	535	P	4 17 W 4 43 W	4
20	α Crucis.	...	12 21	62 31	117.9	10	4.90	7	535	R	2 11 E 1 45 E	4
21	"	...	"	"	117.6	7	...	...	535	R	1 55 E 1 18 E	3
22	γ Centauri	5, 5	12 36	48 23	356.0	10	1.87	7	300	P	2 30 E 2 3 E	4
23	"	...	"	"	355.2	10	2.06	7	300	P	1 23 E 0 56 E	4
24	"	...	"	"	356.3	10	...	...	300	P	2 9 E 1 27 E	4
25	"	...	"	"	355.8	10	1.60	10	535	P	2 9 E 1 27 E	4
26	"	...	"	"	356.7	10	1.53	10	535	...	3 1 E 2 29 E	4 & 3
27	"	...	"	"	356.0	10	...	...	300	P	3 19 E 2 31 E	5
28	"	...	"	"	355.4	10	...	...	535	P	1 54 E 1 28 E	5 & 4
29	"	...	"	"	356.7	10	1.69	7	535	P	2 54 E 2 33 E	4
30	"	...	"	"	356.1	10	1.68	6	300	P	0 53 W 1 17 W	4
31	"	...	"	"	357.6	10	...	...	535	R	1 2 W 1 49 W	4
32	"	5, 5	"	"	358.8	10	1.84	7	535	R	1 34 E 1 6 E	5
33	γ Virginis	...	12 36	0 52	149.8	10	5.74	7	300	P	0 59 E 0 35 E	4
34	"	...	"	"	149.9	10	6.15	6	300	P	3 26 E 2 51 E	3
35	β Muscæ	...	12 40	67 32	335.4	10	1.60	7	300	P		

Ref. No.	Star.	Observed Magnitudes.	Approx. Place of Star 1895 ^o , R. A. h m Dec. S. ° ' "	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Eyes.	h m Hour-angles.	h m Mag. 1 to 5.
36	β Muscæ	$4\frac{1}{2}, 4\frac{1}{2}$	67 32	.301	340°0	10	...	...	300	R	h m 2 5 E	3
37	"	$4\frac{1}{2}, 4\frac{1}{2}$	"	.304	340°0	10	...	...	300	R	h m 1 20 E	3
38	"	...	"	.307	337°8	10	...	...	300	...	h m 3 12 E	4
39	"	...	"	.307	335°5	10	1'23	7	535	...	h m 1 36 W	3
40	"	...	"	.444	335°1	10	...	...	300	P	h m 1 59 W	4
41	"	...	"	.457	337°0	10	...	...	535	P	h m 2 25 E	3
42	α Centauri	...	60 24	.397	207°4	10	20°98	6	300	P	h m 2 54 E	4
43	"	...	"	.400	207°6	10	20°82	10	300	P	h m 4 33 E	5
44	"	...	"	.444	207°9	10	21°18	10	535	P	h m 3 5 E	4
45	"	...	"	.446	208°0	10	20°89	10	535	P	h m 4 36 E	5
46	"	1, 3	"	.449	207°4	10	...	...	300	P	h m 4 19 E	5
47	"	...	"	.452	207°6	10	21°00	5	535	P	h m 1 35 E	4
48	"	...	"	.452	207°4	10	...	...	535	P	h m 2 18 E	5
49	"	1, 3	"	.457	207°7	10	20°89	8	535	P	h m 3 24 E	4
50	"	1, 3	"	.487	207°9	6	...	...	535	P	h m 2 24 W	3
51	"	1, 2	"	.630	208°5	10	20°78	8	300	R	h m 2 15 W	3
52	"	...	"	.690	208°1	10	21°00	10	300	R	h m 4 18 W	2
53	"	1, 2	"	.701	207°9	10	...	...	300	R	h m 2 33 W	4
54	"	1, 3	"	.717	208°3	10	21°07	10	300	R	h m 3 0 W	4

Ref. No.	Star.	Observed Magnitudes.	Approx. Place of Star 1895 ^o . R. A. h m Dec. S. °	Fraction of Year.	Position of Angle.	No. of Obs.	Distance.	No. of Obs.	Mag. Power.	Eyes.	Hour-angles. h m h m	Weight, 1 to 5.
55	α Centauri	...	14 33 60 24	.723	207.8	6	"	...	300	P	4 55 W 5 10 W	4
56	"	...	"	.726	207.6	10	...	...	300	R	1 12 W 1 30 W	2
57	"	...	"	.737	207.9	10	21.11	10	300	R	2 21 W 3 0 W	4
58	π Lupi	} 5, 5	14 58 46 38	{ .307	87.7	10	...	...	535	R	4 11 E 3 40 E	{ 3
59	"				87.0	10	...	...				
60	"	4 $\frac{1}{2}$, 4 $\frac{1}{2}$	"	.318	87.7	10	1.53	6	300	R	3 41 E 3 18 E	4
61	"	5, 5	"	.630	86.4	10	1.64	8	300	R	2 55 W 3 24 W	4
62	"	5, 5	"	.633	86.7	10	1.66	5	300	P	1 23 W 1 58 W	4
63	ρ Ophiuchi	6, 7	16 19 23 12	.742	354.5	10	3.33	7	300	P	2 53 W 3 17 W	3
64	36 Ophiuchi	...	17 9 26 27	.742	195.3	10	4.72	6	300	R	1 3 W 1 26 W	4
65	Brisbane 6556	6, 6	18 54 37 12	.739	281.6	10	12.71	5	300	P	1 52 W 2 15 W	4
66	"	...	"	.742	281.3	10	12.67	5	300	R	2 26 W 2 49 W	4 & 3
67	Lacaille 7924	8, 8	63 56	.783	290.5	10	1.51	6	300	P	3 8 W 3 30 W	4 & 3
68	"	8, 8	"	.786	288.9	10	...	...	300	P	2 2 W 2 28 W	2
69	"	8, 8	"	.789	289.6	10	...	...	300	P	2 5 W 2 31 W	3
70	γ Coronæ Aust.	...	18 59 37 13	.717	162.5	10	...	...	300	R	1 20 W 1 43 W	3
71	"	...	"	.737	161.4	10	1.67	10	300	P	2 2 W 2 33 W	4
72	"	6, 6	"	.739	163.2	10	1.64	8	300	R	1 6 W 1 40 W	3
73	"	6, 6	"	.742	161.7	10	1.46	8	300	P	1 50 W 2 13 W	4

Ref. No.	Star.	Observed Magnitudes.	Approx. Place of Star 1895.0. R. A. h m	Fraction of Year.	Position of Angle.	No. Obs.	Distance.	No. Obs.	Mag. Power.	Eyes.	Hour-angles. h m	Weight, 1 to 5.
74	γ Coroneæ Aust.	...	18 59 37 13	.783	161.3	10	1.77	10	300	P	2 9 W	4
75	"	...	" "	.789	159.4	10	...	...	300	P	2 41 W	3
76	θ Indi	5, 7	21 12 53 53	.871	281.8	10	4.45	7	300	P	2 8 W	4
77	"	5, 8	" "	.917	283.1	10	4.45	8	300	R	3 47 W	2
78	θ Gruis	4½, 8	23 1 44 10	.830	29.3	10	...	...	300	R	1 19 E	2
79	"	...	" "	.871	31.0	10	...	...	300	P	1 1 W	4
80	"	...	" "	.936	21.1	10	...	...	300	P	2 14 W	1
81	"	4, 8½	" "	.947	19.7	12	1.66	7	300	P	2 51 W	3
82	"	4, 8½	" "	.961	31.2	10	...	...	300	R	3 20 W	2

Remarks.

In the column headed "Eyes" P denotes that the line joining the observer's eyes was parallel to that joining the components, and R that these lines were at right angles. The column headed "Hour-angles" gives the hour-angles between which the measures were made, and that headed "Weight" gives the value of each result on a scale of 1 to 5, 1 denoting the worst and 5 the best possible conditions.

The following component of No. 1 was the brighter. The components of Nos. 2, 3, 22, 27, 28, 30, 36, 60, 62, 65, 67, 68, 69, 70, 71, 72, 73, 74, 75, were noted to be equal. The south component of Nos. 9, 10, 35 was probably the brighter. The measures of Nos. 15, 16, 17, 18, 19, 78, 79, 80, 81, 82, were extremely difficult; the discrepancies in the results are due to the great inequality of the components and the faintness of the companions. Nos. 16 and 18 were measured in twilight; 44, 52, 64, partly in sunlight and partly in twilight; and 46, 47, 50, 54, 56, 57, in sunlight. Of No. 76 the primary was white and the companion blue, and of No. 78 the primary was yellowish and the companion bluish.

Q Q

Windsor, N.S. Wales: 1896 January.

*Results of Micrometer Measures of Double Stars made with the
28-inch Refractor at the Royal Observatory, Greenwich, in
the years 1894 and 1895.*

(Communicated by the Astronomer Royal.)

The measures were made with a bifilar position micrometer on the 28-inch refractor. The power generally used was 670, but a power of 1030 was used when observing close pairs, and when the definition permitted. A blue glass shade was employed to diminish the light and irradiation, when bright stars were observed. The observers' initials in the last column, WC, D, M, L, H., WB, GEN, are those of Mr. Christie, Mr. Dyson, Mr. Maunder, Mr. Lewis, Mr. Hollis, Mr. Bowyer, and Mr. Niblett respectively. Fuller details of the observations will be published in due course in the Greenwich volumes for 1894 and 1895.

	Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° ' "	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer
Σ 3062	Bradley 3210	0 0 59	32 9	150.6	1.57	1	6.9 8.0	5.107	D.
OS 2	AB	...	...	151.9	1.58	1	...	5.107	M.
h 1007	AC	0 8 11	63 36	30.8	0.49	2	6.9 8.3	5.857	L.
β 1027		...	...	225.5	17.23	1	6.9 9.6	5.901	"
* β 1093	Lalande 375	0 9 44	69 3	180.5	1.38	1	7.7 11.5	5.901	"
OS 20	66 Piscium	0 15 44	79 34	42.0	...	1	7.3 8.2	5.901	"
		0 49 17	71 21	328.9	0.35	1	5.9 7.0	4.887	"
		...	...	335.0	0.32	2	...	5.895	"
Σ 73	36 Andromedæ	0 49 36	66 55	15.8	1.41	1	6.2 6.8	4.882	"
β 1228	D.M. 12° 133	...	...	11.2	1.28	3	...	5.904	"
β 303		1 0 33	77 13	268.1	0.51	1	8.3 8.9	5.879	"
		1 4 15	66 44	285.7	0.62	3	7.2 7.2	5.914	"
	φ Piscium	1 8 19	65 57	226.4	7.89	1	4.7 10.1	5.912	"
β 1029	BC	1 8 33	82 57	240.1	...	1	7.3 13.5	5.904	D.
Σ 113	42 Ceti	1 14 42	91 2	349.7	1.67	1	6.2 7.2	4.887	L.
β 1164	95 Piscium	1 22 28	84 10	162.4	0.43	2	6.7 7.0	5.492	"
β 506	η Piscium	1 26 8	75 10	25.0	0.63	1	4.0 10.5	5.879	"
β 507		1 30 21	63 44	156.9	2.16	1	8.0 11.0	5.868	"
Σ 138	Piazz1 L. 123	1 30 49	82 52	37.5	1.51	2	7.3 7.3	5.916	"
Σ 155	W.B. (1) L. 666-7	1 38 57	81 1	327.6	4.83	1	7.5 7.9	5.904	D.

* Rough.

	Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° '	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer.
Σ 155	W.B. (1) I. 666-7	1 38 57	81 1	327.3	5.02	1	7.5 7.9	5.912	L.
β 509		1 38 28	80 56	257.5	0.74	1	8.4 8.7	5.912	"
Σ 158		1 40 59	57 20	256.9	2.11	1	8.3 8.8	5.868	"
β 510		1 43 9	74 10	333.9	2.08	1	8.1 10.5	5.901	"
Hough		1 45 40	65 50	351.3	0.36	1	7.5 7.7	4.887	"
		...	...	...	0.51	1	...	5.868	"
Σ 180	γ Arietis	1 48 2	71 12	0.9	8.53	1	4.2 4.4	5.868	"
β 512		1 48 18	71 13	292.0	1.25	1	8.6 11.7	5.868	"
Σ 183	AB	1 49 30	61 41	356.9	0.67	1	7.5 8.2	5.868	"
	AC	...	...	163.5	5.35	1	7.5 8.8	5.868	"
Σ 205	γ ¹ Andromedæ	1 57 45	48 9	63.2	10.33	1	3.0 5.0	5.841	"
OΣ 38	γ ² Andromedæ	1 57 46	48 9	286.6	...	3	5.0 6.2	5.872	D.
		...	...	291.3	0.21	5	...	5.907	L.
Σ 208	10 Arietis	1 57 59	64 33	62.3	1.03	1	6.2 8.4	5.868	"
Σ 228		2 7 37	43 1	69.4	0.37	3	6.7 7.6	5.869	"
β 876	A of Σ 258	2 17 57	56 57	233.6	1.00	1	7.7 11.9	5.868	"
	CD	...	...	33.7	6.14	1	8.9 9.2	5.868	"
β 262		2 41 45	59 22	239.7	1.59	2	8.2 9.6	5.896	"
β 525	Bradley 414	2 53 14	68 47	125.9	0.23	2	7.5 7.5	5.896	"
Σ 333	ε Arietis	2 53 29	69 4	202.3	1.39	2	5.7 6.0	5.896	"
β 1030		3 4 19	73 40	165.0	0.71	2	8.4 8.4	5.924	"

Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° ′	Position Angle. °	Distance. "	No of Nights.	Magnitudes.	Epoch 1890+.	Observer.
Σ 412	7 Tauri	65 52	34.4	0.37	1	6.6 6.9	5.059	D.
OΣ 531	Piazzi III. 242	...	23.1	0.36	2	...	5.466	L.
Σ 535		52 11	127.3	2.45	2	6.5 8.2	5.875	"
β 560		78 51	330.5	2.07	1	6.7 8.2	5.078	"
Σ 1074		...	328.5	1.68	1	...	5.876	D.
β 577		60 18	155.3	0.52	1	8.0 8.5	5.078	L.
Σ 1110	Piazzi VII. 81	89 25	137.4	0.58	2	7.8 8.2	5.193	"
OΣ 182	Castor	...	106.1	14.15	1	7.8 13.5	5.192	"
		57 53	227.9	6.33	1	2.7 3.7	5.274	D.
		...	225.0	6.18	1	...	5.274	L.
		86 21	210.7	1.58	1	7.0 7.5	5.194	D.
		...	...	1.20	1	...	5.194	H.
β 581		...	211.3	1.37	2	...	5.196	L.
	AB	77 25	278.3	0.45	1	8.5 8.6	5.279	"
	AC	...	199.3	4.82	1	8.5 11.5	5.279	"
Σ 1196	ζ Cancri	72 3	21.9	1.23	2	5.0 5.7	5.233	"
	AC	...	117.2	5.10	2	5.0 5.5	5.233	"
	BC	...	127.9	5.58	2	5.7 5.5	5.233	"
Σ 1263	Lalande 17161	47 56	20.6	51.42	1	7.6 8.2	5.296	"
†Σ 1273	ε Hydræ	83 13	231.4	3.74	1	3.8 7.8	5.230	"

† Definition bad.

	Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° ' "	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1900+.	Observer.
Σ 3121		9 11 57	61 0	189.3	0.65	4	7.5 7.8	5.238	L.
OS 201		9 17 59	61 40	223.3	1.40	1	7.5 8.9	5.307	"
Σ 1348		9 19 13	83 13	319.5	1.63	1	7.5 7.6	5.307	"
Σ 1356	ω Leonis	9 23 5	80 30	108.4	0.72	1	6.2 7.0	5.192	"
Σ 1377	Piazzi IX. 161	9 38 17	86 55	138.3	3.68	1	7.9 11.1	5.186	"
Σ 1389		9 46 42	62 33	308.9	2.30	1	8.0 9.0	5.236	"
OS 215	Piazzi X. 23	10 10 49	71 46	209.0	1.01	3	6.7 7.0	5.239	"
Σ 1424	γ Leonis	10 14 7	69 39	114.2	3.64	4	2.0 3.5	5.226	"
		...	...	111.7	3.64	1	...	5.274	D.
Σ 1426	AB	10 15 17	83 4	282.3	1.00	1	7.8 8.3	5.279	L.
	AC	...	...	7.0	4.38	1	7.8 9.3	5.279	"
OS 224	Piazzi X. 128	10 34 29	80 38	321.4	0.47	2	7.2 9.2	5.228	"
OS 228		10 41 51	66 54	189.5	0.62	2	7.2 8.1	5.296	"
Σ 1504	Piazzi X. 229	10 58 49	85 49	282.0	1.56	1	7.5 7.6	5.282	D.
β 915		...	...	226.7	1.14	1	...	5.356	L.
Σ 1523	ξ Ursæ Maj.	11 12 52	57 54	176.0	1.98	1	4.0 4.9	5.326	"
Σ 1536	ι Leonis	11 18 42	78 54	58.2	2.54	2	3.9 7.1	5.280	"
Σ 1555	Piazzi XI. 111	11 31 3	61 40	344.5	0.50	1	6.4 6.8	5.290	D.
		...	...	347.9	0.40	1	...	5.296	L.
	AC	...	...	146.3	21.64	1	6.4 10.3	5.296	"
β 603		11 45 25	75 5	...	1.05	1	...	5.205	D.

Star's Name.	R.A. 1900. h m s	N.P.D. 1900. °	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer.
Σ 1639	12 19 26	63 52'	277.1	0.28	1	6.7 7.9	5.236	L.
Σ 1658	12 30 2	82 0	355.4	2.40	1	8.0 9.8	5.279	"
Σ 1661	12 30 57	78 2	237.3	2.52	1	8.5 8.5	5.350	"
β 112	12 55 45	71 5	...	2.57	1	9.3 9.8	5.408	D.
Piazzi XII. 243 BC	...	...	297.5	2.34	1	...	5.408	L.
Or 266	13 23 33	73 46	337.9	1.47	1	7.3 7.8	5.345	"
β 612	13 34 38	78 42	213 6	0.43	1	6.4 6.5	5.323	"
Σ 1785	13 44 32	62 31	262.2	1.44	1	7.2 7.5	5.460	"
Σ 1877	14 40 37	62 29	336.6	3.21	1	3.0 6.3	5.423	"
Σ 1879	14 41 18	79 56	144.6	0.40	2	7.8 8.8	5.440	"
Σ 1944	15 22 46	83 33	329.5	1.08	1	7.5 8.1	4.509	"
Σ 1967	15 38 33	63 23	123.5	0.54	1	4.0 7.0	4.504	"
Σ 2052	16 24 29	71 23	97.5	2.24	1	7.5 7.5	5.564	"
Σ 2055	16 25 53	87 48	44.9	1.20	1	4.0 6.1	4.509	"
Σ 2084	...	...	43.6	1.25	1	...	5.430	"
ζ Herculis	16 37 31	58 13	40.4	1.23	2	3.0 6.5	4.541	"
Σ 2106	...	...	37.9	0.67	1	...	5.444	"
Σ 2107	16 46 21	80 25	306.8	0.35	2	6.7 8.4	5.527	"
Σ 2114	16 47 53	61 10	286.8	0.49	2	6.5 8.0	5.527	"
	16 57 11	81 24	159.6	1.29	1	6.2 7.4	4.509	"
Piazzi XVI. 270	...	...	154.9	1.20	3	...	5.555	"

Star's Name.	R.A. 1900. h m s	N.P.D. 1900.	Position Angle.	Distance.	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer.
Σ 2120	17 0 48	61 46	246°6	7°03	1	6·4 9·2	5'578	L.
Σ 2140	17 10 5	75 28	117°5	4°87	1	3·0 6·1	4'528	"
	...	...	115°8	4°98	1	...	5'515	"
Σ 2173	17 25 15	90 59	336°8	1°15	2	5·8 6·1	4'541	"
Σ 2205	17 40 6	72 14	308°3	2°15	1	8·3 8·7	5'611	"
β 631	17 34 47	90 36	69°8	0°37	1	7·5 7·6	5'682	"
Σ 2215	17 41 17	72 15	292°6	0°72	2	5·9 7·9	5'595	"
A.C. 7	17 42 33	62 13	42°9	1°46	1	10·0 10·1	5'482	"
O Σ 337	17 45 40	82 44	98°6	0°44	1	7·5 8·0	5'682	"
O Σ 338	17 47 27	74 39	17°2	0°81	2	6·6 6·9	5'666	"
	...	...	17°5	0°63	1	...	5'723	D.
Σ 2272	18 0 23	87 29	295°9	2°65	1	4·1 6·1	5'693	L.
A.C. 15	18 3 14	59 28	293°4	0°34	2	6·0 11·5	5'652	"
Σ 2289	18 5 50	73 33	233°5	1°02	2	6·0 7·1	5'701	"
	...	...	233°3	1°24	1	...	5'723	D.
Σ 2315	18 21 0	62 40	199°6	0°24	1	7·9 8·6	4'531	L.
	...	...	222°9	0°37	2	...	5'527	"
	18 19 30	62 41	317°9	4°75	1	9·0 10·0	5'487	"
O Σ 357	18 31 15	78 21	252°5	0°34	1	7·5 7·6	5'660	"
O Σ 358	18 31 35	73 6	197°3	1°98	1	6·8 7·2	5'660	"
Σ 2400	18 44 26	73 52	188°0	1°91	3	8·0 11·1	5'667	"

AB

	Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° ' "	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer.
Σ 2400	AC	18 44 26	73° 52'	194.4	3.12	3	8.0 11.0	5.667	L.
	AD	...	...	202.3	0.70	2	8.0 9.5	5.633	"
	AD	...	...	202.5	...	1	...	5.654	D.
Σ 2402		18 45 2	79 26	206.4	1.20	2	8.0 8.4	5.694	L.
β 648	B.A.C. 6480	18 53 14	57 14	237.9	1.49	3	6.0 9.8	5.590	"
Σ 2424	11 Aquilæ	18 54 28	76 31	263.6	16.97	1	5.7 9.2	5.687	"
		...	...	265.7	17.01	1	...	5.687	W.B.
		...	...	264.1	17.11	1	...	5.687	N.
Σ 2525		19 22 30	62 53	327.5	0.37	1	7.4 7.6	5.654	D.
		...	...	325.3	0.35	2	...	5.686	L.
Σ 2536		19 27 5	72 25	71.7	2.14	2	8.0 11.0	5.689	"
		19 27 20	72 9	141.0	4.54	1	10.0 11.0	5.720	"
Σ 2556		19 35 7	67 58	148.5	0.43	2	7.3 7.8	5.686	"
A.G.C. 11	ζ Sagittæ	19 44 32	71 6	171.7	0.24	2	4.5 6.0	5.686	"
Σ 2585	AC	...	...	312.0	8.81	1	...	5.715	"
O Σ 395	16 h Vulpeculæ	19 57 46	65 20	101.6	0.53	2	5.8 6.2	5.723	"
		...	...	99.6	0.57	1	...	5.726	D.
Σ 2695		20 27 41	64 32	81.6	1.07	3	6.2 8.0	5.722	L.
β 151	β Delphini	20 32 51	75 45	350.3	0.66	2	4.5 6.0	5.691	D.
D D	AB	...	...	351.9	0.65	1	...	5.813	L.
Σ 2704	β Delphini	...	...	117.8	26.14	1	4.5 11.0	5.813	"

	Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° ' "	Position Angle. °	Distance. "	No. of Nights.	Magnitudes.	Epoch 1890+.	Obs. rev.
Σ 2704	β Delphini	AD 20 32 51	75 45	331.2	...	1	4.5 11.0	5728	D.
		AD	...	331.0	36.66	1	...	5813	L.
Σ 2729	4 Aquarii	20 46 8	96 0	191.8	0.20	1	5.9 7.2	5813	"
Σ 2737	ε Equulei	AB 20 54 5	86 5	284.4	0.77	2	5.7 6.2	5734	"
		AC	...	72.6	10.60	2	5.7 7.1	5734	"
Σ 2744		20 57 58	88 52	168.3	1.40	1	6.3 7.0	5737	"
Σ 2749		AB 20 59 43	86 52	156.6	2.77	1	7.7 8.9	5737	"
		AC	...	154.6	4.43	2	...	5712	"
		AD	...	153.0	0.59	1	...	5737	"
		BC	...	154.6	1.07	1	...	5737	"
Ho. 152		21 8 11	62 4	328.7	0.47	2	...	5709	"
β 163		21 13 45	78 51	246.9	0.63	2	7.2 9.8	5696	"
β 838		21 15 52	87 18	101.3	1.36	1	8.3 9.2	5737	"
Σ 2799		21 24 1	79 19	119.4	1.22	4	6.6 6.6	5717	"
		...	...	123.4	1.57	2	...	5725	D.
Σ 2804		21 28 20	69 44	333.0	2.94	1	7.0 8.0	5726	"
		...	...	331.9	2.97	2	...	5732	L.
Σ 2822	μ Cygni	21 39 40	61 42	123.2	2.91	3	4.0 5.0	5746	"
Σ 2824	κ Pegasi	AC 21 40 7	64 49	298.8	12.19	2	3.9 10.8	4816	"
		...	...	298.9	12.24	2	...	5689	"
β 989		...	...	114.8	0.14	4	3.9 5.0	4844	"

Star's Name.	R.A. 1900. h m s	N.P.D. 1900. ° '	Position Angle.	Distance.	No. of Nights.	Magnitudes.	Epoch 1890+.	Observer.
β 989	AB	21 40 7	64 49	104° 1'	0° 12'	5	3.9 5.0	L. 5705
		...	...	104° 3'	...	2	...	D. 5727
		...	...	103° 0'	...	1	...	W.C. 5731
		...	...	105° 8'	0° 11'	2	...	L. 5846
β 75		...	...	...	0° 10'	1	...	D. 5879
Σ 2849		21 50 40	79 35	37° 0'	1° 14'	3	8.1 8.3	L. 5755
		21 53 2	70 16	264° 0'	1° 41'	2	8.2 10.7	" 5732
		21 53 0	69 42	85° 1'	2° 13'	1	...	" 5726
Σ 2878		22 9 32	82 31	126° 5'	1° 19'	4	6.5 8.0	" 4826
Σ 2881		22 10 0	61 55	101° 3'	1° 58'	2	7.7 8.2	" 5712
β 1216	Lalande 43605	22 15 37	60 59	312° 5'	0° 52'	3	8.4 8.7	" 5746
β 1218	W.B. (2) XXII. 476	22 23 28	60 49	52° 8'	1° 76'	2	8.6 8.8	" 5775
Σ 2900	33 Pegasi	22 18 50	69 39	176° 9'	1° 69'	1	6.0 9.2	" 5737
Σ 2934		22 37 0	69 8	150° 2'	1° 00'	1	8.2 9.2	" 5731
β 710		22 37 53	60 48	52° 3'	0° 43'	1	8.3 8.5	" 5813
β 80		23 13 42	85 9	325° 1'	0° 63'	1	8.1 8.7	" 4846
Hough	Σ 3002 = AB	23 15 43	88 6	202° 5'	4° 10'	1	7.9 10.7	" 4846
	AC	...	...	204° 3'	5° 74'	1	7.9 11.2	" 4846
	Hough = BC	...	...	213° 5'	0° 89'	1	10.7 11.2	" 4846
85 Pegasi	AC	23 56 56	63 26	350° 0'	28° 86'	1	6.0 9.0	" 5058
β 733	AB	...	...	177° 6'	0° 65'	2	6.0 11.0	" 4979
		...	...	196° 3'	0° 47'	2	...	" 5857

NEEDS IN SCIENCE
AND LIFE